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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR—80TH MERIDIAN AND U.S. LOCATIONS, DECEMBER 1964. (Health and Safety Laboratory, U.S. Atomic Energy Commission). *Radiological Health Data, Vol. 6, July 1965*, pp. 343–50.

As part of continuing studies initiated in January 1963, the Atomic Energy Commission measures fission product gamma activity in air on a weekly basis at various locations above and below the Equator. Summarized results presented for 1964 reveal a distinct increase in gamma activity in the Northern Hemisphere following the Chinese nuclear test of October 16, but for the same period there was a decline in gamma activity in the Southern Hemisphere. Longitudinal variations in fission product gamma activity in surface air are discussed in some detail.

RADIOSTRONTIUM IN CALIFORNIA MILK, JANUARY 1960 THROUGH JUNE 1963. *A. E. Greenberg, A. C. Cornish, G. S. Uyesugi, and J. M. Heslep* (California Department of Public Health). *Radiological Health Data, Vol. 6, July 1965*, pp. 367–70.

Data on observed strontium-90 concentrations in California milk from January 1960 through June 1963 are presented and analyzed. Levels within the State show variations comparable to the lowest and the highest values reported anywhere in the United States. These large differences are due in part to geographical and climatic conditions in which rainfall with its attendant burden of fission products is the single most important factor. Climate alone does not account for all the differences; agricultural practices must also play a significant role.

ESTIMATES OF THE CONCENTRATIONS OF STRONTIUM-89, STRONTIUM-90, and CESIUM-137 IN MILK AS A FUNCTION OF TIME AFTER AN ACUTE LOCALIZED CONTAMINATING EVENT. *Report of Ad Hoc Panel on Environmental Factors, Federal Radiation Council. Radiological Health Data, Vol. 6, July 1965*, pp. 383–92.

This report examines various environmental problems related to human exposure that could occur subsequent to an acute localized contaminating event. Particular attention is directed to the transmission of contaminating nuclides to man via the pasture-to-cow-to-fresh-milk pathway. Included are a number of graphs and charts of interest to those having responsibilities in conducting environmental radiation surveillance and countermeasure programs.

Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess total human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

1. Radiation Surveillance Network
March 1965

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The daily field readings are submitted to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are observed, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1800 cubic meters or air are drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a strontium-90—yttrium-90 standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 2000 cpm or higher. The initial 4-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. By using the two counts

4

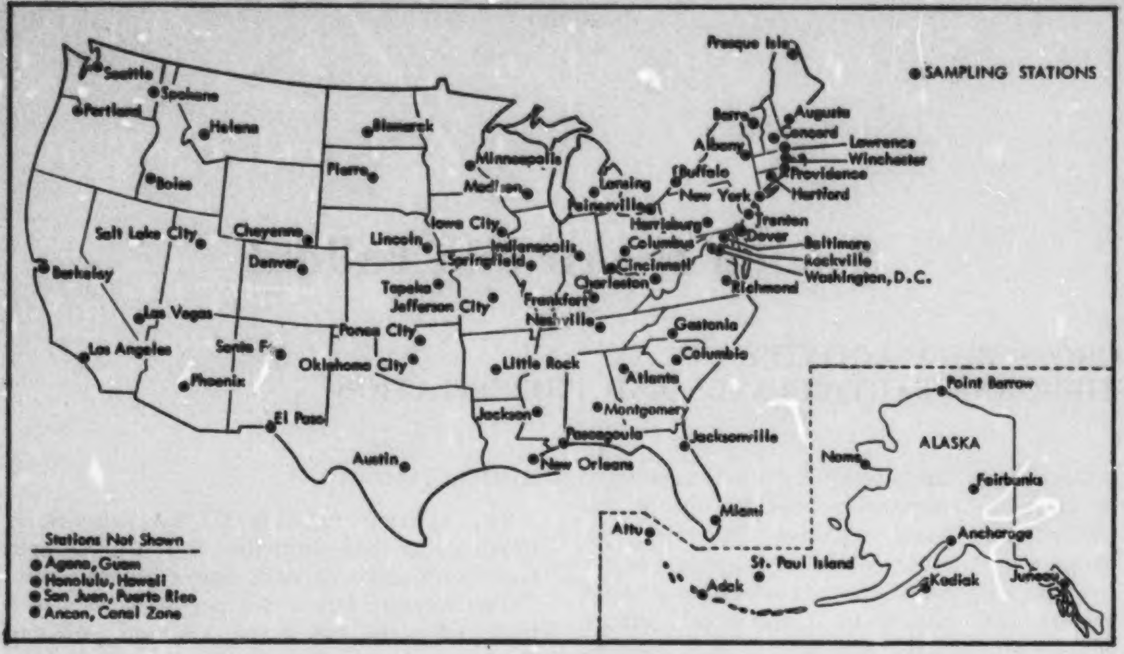
SAMPLING STATIONS
Presque Isle
Seattle
Spokane
Portland
Helena
Bismarck
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
New York
Pierre
Boise
Madison
Lansing
Painesville
Harrisburg
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Columbus
Cincinnati
Charleston
Richmond
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Gastonia
Columbia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Atlanta
Phoenix
El Paso
Jackson
Montgomery
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the day of collection.[1] The March 1965 average gross beta concentrations in air for RSN stations are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

During March 1965, three air samples were analyzed by gamma spectrometry. The method discussed by Burrus (*3*) and Covell (*4*) has been adapted for resolving the spectral data. No air or precipitation samples were found to contain short-lived radionuclides.

Radioactivity in Precipitation

Continuous sampling for radioactivity in total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nCi/m^2, C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month. Total depths and deposition of radioactivity during March 1965 are presented in table 1.

---

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

Table 1. Gross beta activity in surface air and precipitation, March 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pCi/m³)			Last profile in *RHD*	Total depth (mm)	Total deposition (nCi/m²)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	[illegible]	<0.10	<0.21	May 65	185.3	37.1
Alaska:	Adak	22	[illegible]	<0.10	<0.13	Nov 64	[b] —	—
	Anchorage	30	[illegible]	<0.10	<0.15	May 65	13.6	2.7
	Attu Island	20	[illegible]	<0.10	<0.16	Dec 64	—	—
	Fairbanks	11	0.99	<0.10	<0.14	June 65	7.9	1.7
	Juneau	9	0.60	<0.10	0.28	July 65	3.0	0.6
	Kodiak	15	0.17	<0.10	<0.10	Oct 64	—	—
	Nome	15	0.25	<0.10	<0.12	Feb 65	—	—
	Point Barrow	31	0.25	<0.10	<0.12	Jan 65	—	—
	St. Paul Island	22	0.21	<0.10	<0.11	Mar 65	—	—
Ariz:	Phoenix	29	1.05	0.23	0.53	July 65	—	—
Ark:	Little Rock	26	0.49	<0.10	0.21	June 65	94.8	19.9
Calif:	Berkeley	29	0.58	<0.10	0.26	Oct 64	37.8	8.2
	Los Angeles	31	0.86	<0.10	0.38	Feb 65	31.3	7.1
C. Z:	Ancon	18	0.19	<0.10	<0.12	Nov 64	—	—
Colo:	Denver	27	0.64	0.17	[illegible]	Oct 64	8.3	1.7
Conn:	Hartford	30	0.42	<0.10	<0.21	July 65	33.5	8.1
Del:	Dover	22	0.45	<0.10	<0.23	May 65	—	—
D. C:	Washington	29	0.50	<0.10	0.27	Feb 65	103.4	21.4
Fla:	Jacksonville	30	0.48	<0.10	<0.19	June 65	78.3	15.7
	Miami	30	0.75	<0.10	0.29	July 65	58.5	11.7
Ga:	Atlanta	19	0.27	<0.10	<0.15	Apr 65	41.8	8.5
Guam:	Agana	31	0.52	<0.10	0.19	Apr 65	—	—
Hawaii:	Honolulu	30	0.44	0.11	0.26	Dec 64	20.0	4.9
Idaho:	Boise	30	0.71	<0.10	0.36	Dec 64	14.6	2.9
Ill:	Springfield	29	0.41	<0.10	0.21	Feb 65	—	—
Ind:	Indianapolis	29	0.44	<0.10	0.21	Apr 65	47.2	10.2
Iowa:	Iowa City	30	0.60	<0.10	0.30	Nov 64	68.5	14.6
Kans:	Topeka	26	0.43	0.12	0.23	May 65	34.3	6.9
Ky:	Frankfort	23	0.45	<0.10	0.22	Feb 65	[illegible]	15.2
La:	New Orleans	26	0.41	<0.10	<0.18	Feb 65	[illegible]	22.3
Maine:	Augusta	17	0.67	0.13	0.28	Mar 65	—	—
	Presque Isle	30	0.56	<0.10	0.28	Nov 64	20.7	4.3
Md:	Baltimore	22	0.38	<0.10	<0.21	July 65	39.9	8.0
	Rockville	17	0.32	<0.10	<0.17	Jan 65	—	—
Mass:	Lawrence	31	0.50	<0.10	0.25	May 65	47.6	9.9
	Winchester	10	0.34	<0.10	<0.19	Dec 64	34.9	7.0
Mich:	Lansing	31	0.56	<0.10	0.27	Jan 65	—	—
Minn:	Minneapolis	21	0.30	<0.10	0.16	Apr 65	71.8	14.3
Miss:	Jackson	[illegible]	0.42	<0.10	<0.20	Mar 65	149.2	29.9
	Pascagoula	[illegible]	0.18	<0.10	<0.11	Dec 64	—	—
Mo:	Jefferson City	31	0.39	<0.10	0.20	Apr 65	60.2	18.6
Mont:	Helena	28	1.06	<0.10	0.36	Nov 64	21.0	4.5
Nebr:	Lincoln	22	0.79	<0.10	0.27	Mar 65	38.4	10.2
Nev:	Las Vegas	27	1.06	0.25	0.66	June 65	—	—
N. H:	Concord	21	0.60	<0.10	0.32	Feb 65	—	—
N. J:	Trenton	31	0.41	<0.10	<0.20	Mar 65	24.3	5.0
N. Mex:	Santa Fe	19	0.49	0.11	0.25	Nov 64	11.1	3.0
N. Y:	Albany	22	0.42	<0.10	0.23	Apr 65	31.7	6.3
	Buffalo	29	0.64	<0.10	0.28	Nov 64	—	—
	New York	31	0.52	<0.10	0.25	Dec 64	—	—
N. C:	Gastonia	28	0.61	<0.10	<0.24	Nov 64	151.0	30.8
N. Dak:	Bismarck	27	0.31	<0.10	0.17	Jan 65	12.8	2.7
Ohio:	Cincinnati	20	0.47	<0.10	0.21	May 65	—	—
	Columbus	30	0.79	<0.10	0.35	Mar 65	57.9	13.1
	Painesville	28	0.66	0.11	0.33	July 65	55.3	13.6
Okla:	Oklahoma City	29	0.42	<0.10	0.21	Jan 65	—	—
	Ponca City	31	0.27	<0.10	<0.14	July 65	30.7	6.1
Ore:	Portland	31	1.31	0.18	0.64	Mar 65	12.2	2.5
Pa:	Harrisburg	31	0.47	<0.10	<0.17	Apr 65	42.5	8.5
P. R:	San Juan	30	0.20	<0.10	<0.12	Mar 65	7.5	1.5
R. I:	Providence	29	0.53	<0.10	0.26	Jan 65	30.1	8.3
S. C:	Columbia	28	0.43	<0.10	<0.19	Dec 64	177.3	35.6
S. Dak:	Pierre	31	0.42	<0.10	0.21	July 65	—	—
Tenn:	Nashville	30	0.63	<0.10	0.24	Jan 65	130.6	29.1
Tex:	Austin	30	0.68	<0.10	0.26	May 65	42.0	11.4
	El Paso	31	0.90	0.13	0.51	Jan 65	1.3	0.3
Utah:	Salt Lake City	28	0.55	0.18	0.33	Feb 65	5.1	3.4
Vt:	Barre	27	0.66	<0.10	0.36	June 65	9.8	2.0
Va:	Richmond	28	0.34	<0.10	<0.17	June 65	104.3	21.6
Wash:	Seattle	30	0.78	<0.10	0.32	May 65	9.1	2.2
	Spokane	31	0.50	<0.10	0.28	Apr 65	—	—
W. Va:	Charleston	30	0.42	<0.10	0.23	Dec 64	106.2	24.3
Wis:	Madison	30	0.46	<0.10	0.24	June 65	54.0	11.5
Wyo:	Cheyenne	29	0.83	0.12	0.35	June 65	15.9	3.0
Network summary [c]		1958	1.31	<0.10	<0.25			

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] Dash indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

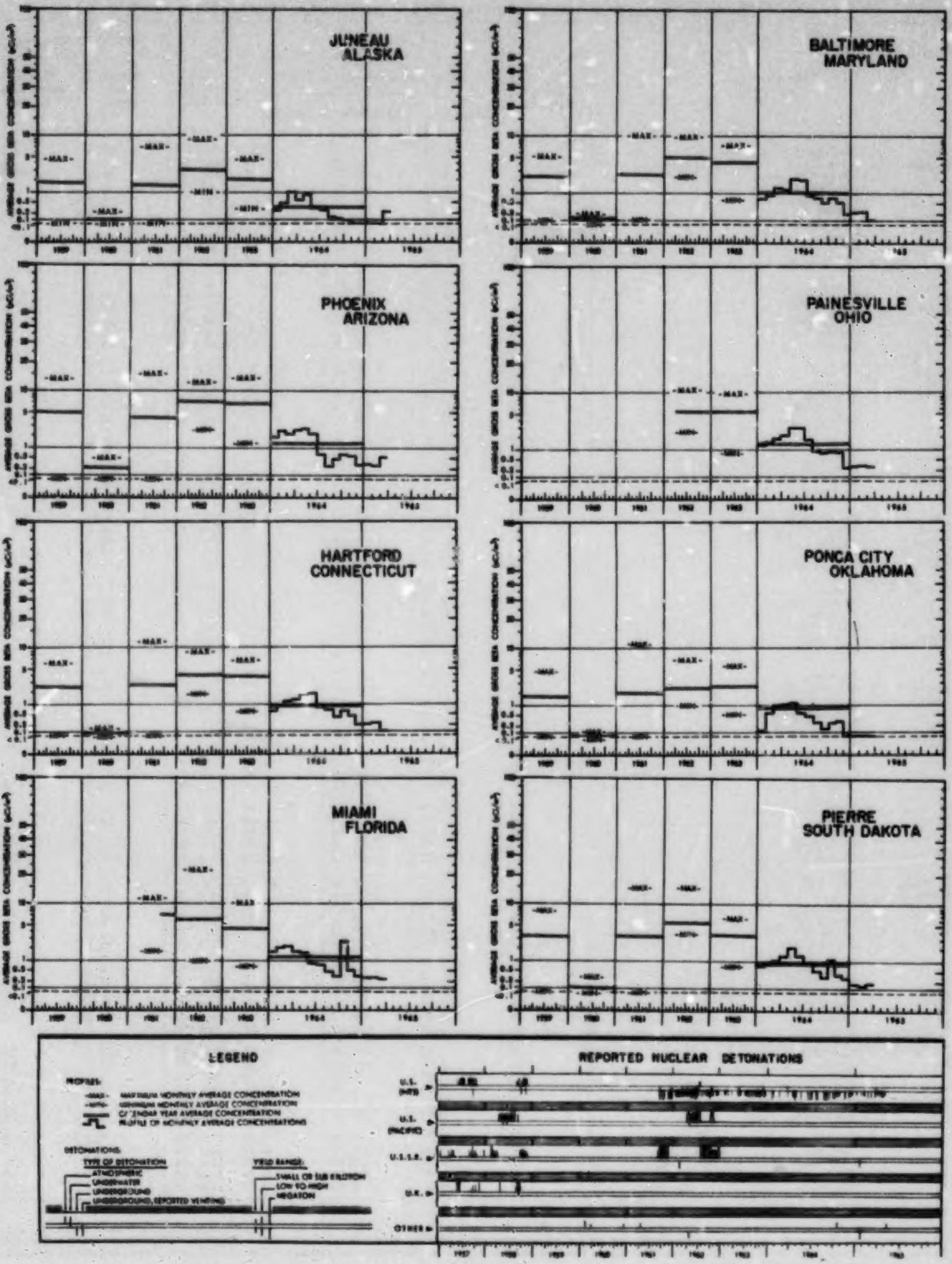

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–March 1965

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2. National Air Sampling Network, First Quarter 1965

Division of Air Pollution, Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate and other factors.

Gross beta activity in air

NASN stations (figure 3) are manned by cooperating Federal, State and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. First quarter 1965 gross beta activities in air are given in table 2. An annual summary for 1964 was presented in the April 1965 issue of *RHD* (*5*).

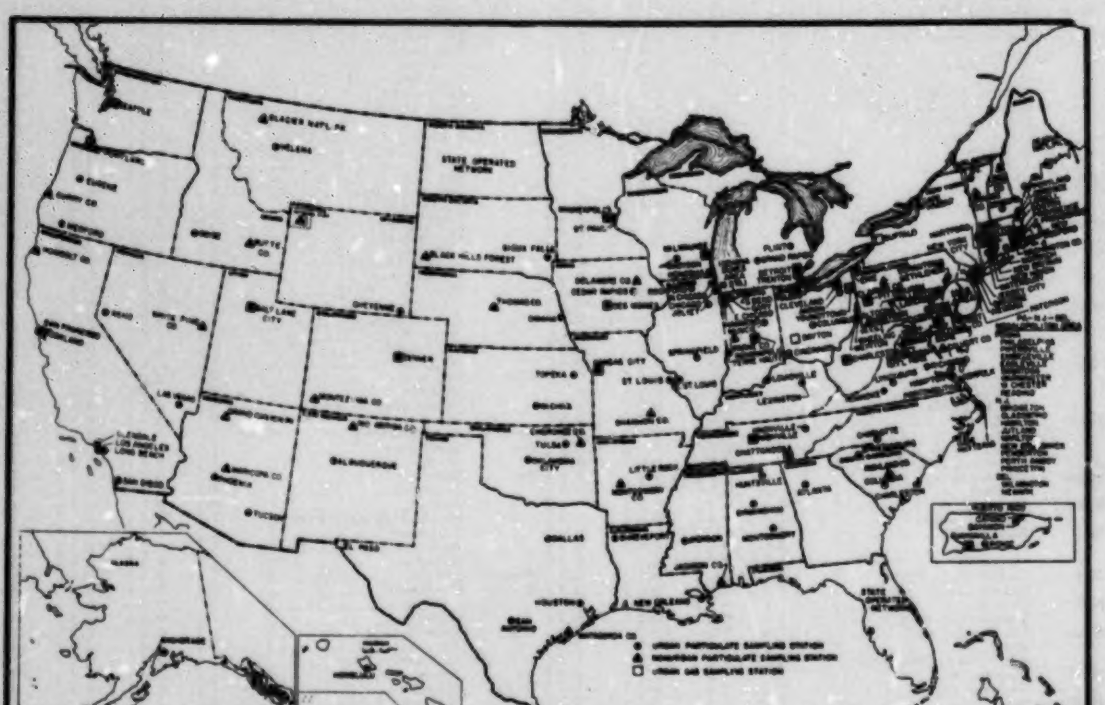

● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ URBAN GAS SAMPLING STATION

Figure 3. National Air Sampling Network stations

8

Table 2. Gross beta activity in surface air, NASN, first quarter, 1965

(Concentrations in pCi/m³)

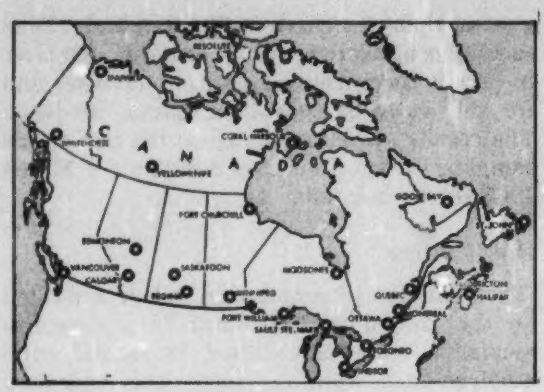
Station Name		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	7	0.6	0.2	0.4
	Huntsville	7	0.5	0.2	0.4
	Montgomery	6	0.6	0.2	0.4
Alaska:	Anchorage	7	0.6	0.1	0.4
Ariz:	Grand Canyon Pk.[a]	6	0.9	0.1	0.4
	Maricopa County [a]	7	1.6	0.2	0.6
	Phoenix	7	1.5	0.2	0.7
	Tucson	6	1.0	0.2	0.5
Ark:	Little Rock	6	0.6	0.1	0.3
	Montgomery County [a]	5	0.5	0.1	0.3
Calif:	Glendale	6	1.2	0.2	0.6
	Humboldt County [a]	6	0.6	<0.1	0.2
	Long Beach	7	1.4	0.2	2.4
	Los Angeles	6	1.2	0.3	0.8
	Oakland	7	0.7	0.1	0.4
	San Diego	6	0.6	0.2	0.4
	San Francisco	7	0.7	0.1	0.3
Colo:	Denver	7	1.0	0.2	0.5
	Montezuma County [a]	6	1.4	0.2	0.7
Conn:	Hartford	7	0.5	0.3	0.4
	New Britain	7	0.8	0.3	0.4
	New Haven	7	0.5	0.3	0.4
	Norwich	7	0.6	0.3	0.4
	Waterbury	7	0.5	0.2	0.4
Del:	Kent County [a]	7	0.5	0.1	0.3
	Newark	7	0.5	0.2	0.3
	Wilmington	7	0.7	0.2	0.4
D. C:	Washington	6	0.4	0.2	0.3
Ga:	Atlanta	6	0.7	0.1	0.4
Hawaii:	Honolulu	7	0.5	0.1	0.3
Idaho:	Boise	7	0.7	0.1	0.4
	Butte County [a]	7	0.8	<0.1	0.3
Ill:	Chicago	5	0.6	0.2	0.4
	East St. Louis	7	0.5	0.1	0.4
	Joliet	6	0.5	0.3	0.4
	North Chicago	7	0.5	0.2	0.3
	Rockford	6	0.5	0.2	0.3
	Springfield	7	0.5	0.2	0.3
Ind:	East Chicago	7	0.5	0.2	0.4
	Hammond	7	0.5	0.2	0.3
	Indianapolis	6	0.5	0.2	0.4
	Muncie	5	0.6	0.2	0.4
	Parke County [a]	7	0.7	0.3	0.4
	Portage	7	0.5	0.2	0.4
	Beverly Shores	7	0.5	0.2	0.3
	Dunes Police Post No. 1	7	0.5	0.2	0.3
	Dunes State Park	7	0.4	0.2	0.3
	Ogden Dunes	7	0.4	<0.1	0.2
	South Bend	7	0.6	0.2	0.3
	Terre Haute	7	0.5	0.3	0.4
Iowa:	Cedar Rapids	7	0.4	0.2	0.3
	Delaware County [a]	7	0.4	0.2	0.3
	Des Moines	7	0.4	0.2	0.3
Kans:	Topeka	7	0.6	0.1	0.3
	Wichita	7	0.5	0.1	0.3
Ky:	Lexington	6	0.8	0.3	0.5
	Louisville	6	0.5	0.3	0.4
La:	New Orleans	7	0.6	0.1	0.4
	Shreveport	7	0.4	0.2	0.3
Maine:	Acadia Nat'l. Park [a]	7	0.7	0.2	0.4
	Portland	7	0.5	0.1	0.3
Md:	Baltimore	7	2.4	0.1	0.6
	Calvert County [a]	7	0.6	0.2	0.3
Mass:	Brockton	7	0.6	0.3	0.4
	Lawrence	7	0.8	0.2	0.5
	Lowell	7	0.7	0.2	0.5
	New Bedford	7	0.9	0.5	0.6
Mich:	Detroit	7	0.7	0.3	0.4
	Flint	7	0.4	0.1	0.3
	Grand Rapids	7	0.7	0.1	0.4
	Trenton	7	0.5	0.2	0.3
Minn:	Minneapolis	7	0.5	0.2	0.3
	St. Paul	7	0.5	0.2	0.3
Miss:	Jackson	7	0.8	0.2	0.4
	Jackson County [a]	7	0.4	0.2	0.3
Mo:	Kansas City	7	0.7	0.2	0.4
	St. Louis	7	0.5	0.2	0.3
	Shannon County [a]	7	0.7	0.2	0.4
Mont:	Glacier Nat'l. Park [a]	6	0.5	0.1	0.3
	Helena	7	1.0	0.2	0.5
Nebr:	Omaha	7	0.6	0.1	0.3
	Thomas County [a]	7	0.6	0.2	0.4
Nev:	Las Vegas	7	1.2	0.2	0.8
	Reno	6	1.1	0.1	0.6
	White Pine County [a]	6	0.8	0.1	0.4
N. H:	Concord	7	0.5	0.3	0.4
	Coos County [a]	7	0.6	0.2	0.4
N. J:	Bayonne	7	0.5	0.1	0.3
	Bridgeton	7	0.8	0.2	0.4
	Pemberton	7	0.5	0.1	0.3
	Marlton	7	0.7	0.1	0.4
	Glassboro	7	0.5	0.2	0.3
	Hamilton	6	0.5	0.1	0.3
	Jutland	6	0.7	0.3	0.4
	Jersey City	7	0.5	0.1	0.3
	Newark	7	0.5	0.1	0.3
	New Brunswick	7	0.4	0.1	0.3
	Paterson	7	0.5	0.2	0.4
	Perth Amboy	7	0.5	0.3	0.4
	Princeton	7	0.5	0.1	0.3
N. Mex:	Albuquerque	7	0.9	0.1	0.4
	Rio Arriba County [a]	6	1.0	0.1	0.5
N. Y:	Cape Vincent [a]	7	0.6	0.3	0.4
	New York City	7	0.7	0.2	0.4
N. C:	Charlotte	7	1.2	0.2	0.4
	Cape Hatteras [a]	7	0.6	0.2	0.4
Ohio:	Akron	7	0.7	0.3	0.4
	Cincinnati	6	0.6	0.3	0.4
	Cleveland	7	0.5	0.1	0.3
	Columbus	7	0.5	0.2	0.3
	Toledo	7	0.5	0.2	0.3
	Youngstown	7	0.5	0.2	0.3
Okla:	Cherokee County [a]	7	0.4	0.2	0.3
	Oklahoma City	7	0.4	0.1	0.3
	Tulsa	7	0.4	0.1	0.3
Ore:	Curry County [a]	6	0.5	<0.1	0.3
	Eugene	7	0.5	<0.1	0.2
	Medford	7	0.9	<0.1	0.3
	Portland	7	0.8	<0.1	0.4
Pa:	Allentown	7	0.5	0.1	0.4
	Altoona	5	0.7	0.1	0.4
	Bethlehem	7	0.5	0.1	0.3
	Pipersville	6	0.4	0.1	0.3
	Embreeville	7	0.4	0.2	0.3
	Clarion County [a]	7	0.5	0.2	0.3
	Erie	7	0.5	0.2	0.4
	Johnstown	6	0.5	0.2	0.4
	Lancaster	7	0.6	0.1	0.3
	Eagleville	7	0.4	0.1	0.2
	Sanatoga	7	0.4	0.2	0.3
	Philadelphia	7	0.4	0.2	0.3
	Pittsburgh	7	0.6	0.2	0.3
	Reading	7	0.6	0.1	0.4
	Scranton	4	0.4	0.2	0.3
	Warminster	6	0.5	0.2	0.4
	West Chester	7	0.4	0.2	0.3
	York	7	0.8	0.1	0.5
P. R:	Bayamon	6	0.6	0.1	0.3
	Guayanilla	3	0.7	0.1	0.4
	Ponce	3	0.4	0.2	0.3
	San Juan	7	0.2	0.1	0.2
R. I:	East Providence	7	0.6	0.1	0.3
	Providence	7	0.6	0.2	0.4
	Washington County [a]	7	0.7	0.2	0.4
S. C:	Charleston	7	0.8	0.1	0.4
	Columbia	6	1.7	0.2	0.9
	Richland County [a]	6	0.6	0.3	0.4
	Spartanburg	6	0.5	0.1	0.3
S. Dak:	Black Hills Forest [a]	7	0.7	0.1	0.4
	Sioux Falls	7	0.6	0.2	0.4
Tenn:	Chattanooga	7	0.7	0.1	0.4
	Knoxville	7	0.5	0.1	0.3
	Memphis	7	0.6	0.3	0.4
	Nashville	7	0.5	0.3	0.4
Tex:	Dallas	7	0.6	0.1	0.4
	Houston	6	0.5	0.3	0.4
	Matagorda County [a]	6	0.7	0.3	0.4
	San Antonio	7	0.6	0.1	0.4
Utah:	Salt Lake City	7	0.8	0.2	0.5
Vt:	Burlington	7	0.6	0.2	0.4
	Orange County [a]	7	0.5	0.3	0.4
Va:	Hampton	7	0.5	0.1	0.3
	Lynchburg	7	0.7	0.1	0.4
	Norfolk	6	0.7	0.2	0.4
	Shenandoah Nat'l. Park [a]	7	0.6	0.1	0.4
	Portsmouth	7	0.4	0.2	0.3
	Richmond	7	0.7	0.1	0.4
	Roanoke	7	0.9	0.3	0.5
Wash:	Seattle	7	0.5	0.1	0.2
W. Va:	Charleston	7	0.6	0.3	0.4
	Weirton	7	0.4	0.2	0.3
	Wheeling	7	0.5	0.1	0.3
Wis:	Door County [a]	5	0.5	0.2	0.3
	Kenosha	7	0.6	0.3	0.4
	Madison	7	0.5	0.2	0.3
	Milwaukee	7	0.5	0.2	0.4
Wyo:	Cheyenne	7	0.6	0.2	0.4
	Yellowstone Park [a]	7	0.9	0.2	0.5
Network summary		1,185	2.4	<0.1	0.4

[a] Denotes nonurban station.

3. Canadian Air Monitoring Program[2]
March 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*6–10*).


RESOLUTE
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CORAL HARBOUR
FORT CHURCHILL
GOOSE BAY
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 4. Canadian air and precipiation sampling stations

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. A 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with

Table 3. Gross beta activity in surface air and precipitation, Canada, March 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pCi/m³)			Average concentration, (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.7	0.1	0.4	188	3.0
Coral Harbour	31	0.5	0.1	0.2	110	1.8
Edmonton	31	0.4	0.1	0.3	138	1.6
Ft. Churchill	31	0.5	0.1	0.2	211	1.2
Ft. William	31	0.5	0.2	0.3	116	4.0
Fredericton	30	0.5	0.0	0.2	107	2.5
Goose Bay	31	0.4	0.0	0.2	46	5.1
Halifax	31	0.5	0.0	0.2	92	3.8
Inuvik	31	0.5	0.2	0.3	175	1.8
Montreal	31	0.6	0.1	0.3	141	2.6
Moosonee	31	0.5	0.2	0.3	171	1.1
Ottawa	31	0.5	0.1	0.3	99	2.0
Quebec	31	0.4	0.1	0.3	246	4.1
Regina	31	0.4	0.0	0.3	467	2.7
Resolute	28	0.5	0.2	0.3	362	2.0
St. John's, Nfld	29	0.2	0.0	0.1	72	9.1
Saskatoon	31	0.3	0.1	0.2	554	1.7
Sault Ste. Marie	31	0.6	0.2	0.3	73	2.2
Toronto	30	0.5	0.1	0.3	75	4.2
Vancouver	31	0.6	0.0	0.4	227	9.8
Whitehorse	31	0.5	0.1	0.3	361	1.5
Windsor	30	0.6	0.1	0.3	98	7.4
Winnipeg	31	0.4	0.2	0.3	120	1.6
Yellowknife	31	0.4	0.1	0.2	504	1.6
Network summary	736	0.7	0.0	0.3	198	3.3

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 4: 19–25 (April 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

a strontium-90—yttrium-90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for March 1965 are given in table 3.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is then ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a strontium-90—yttrium-90 source. Gross beta activities for March 1965 samples are given in table 3. Radionuclide analyses are reported quarterly in *RHD*.

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4. Mexican Air Monitoring Program
March 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*11–15*).

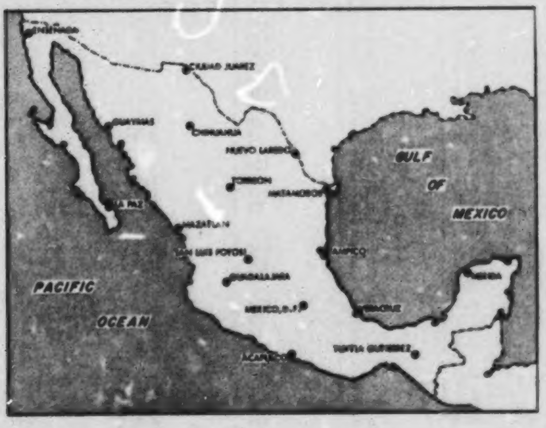

Figure 5. Fallout Network sampling stations in Mexico

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This consists of 17 stations (figure 5), twelve of which are located at airports and operated by airline personnel. The other stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during March 1965 are presented in table 4.

Table 4. Gross beta activity of airborne particulates, Mexico, March 1965

Station	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	19	0.1	<0.1	0.1
Ciudad Juárez	17	0.3	<0.1	0.1
Chihuahua	17	0.5	<0.1	0.2
Ensenada	11	0.4	<0.1	0.2
Guadalajara	9	0.1	<0.1	0.1
Guaymas	5	0.2	<0.1	0.1
La Paz	6	0.6	0.1	0.3
Matamoros[a]				
Mazatlán[a]				
Mérida	11	0.3	<0.1	0.1
México, D.F.	13	0.3	<0.1	0.1
Nuevo Laredo[a]				
San Luis Potosí	13	0.2	<0.1	<0.1
Tampico	17	0.3	<0.1	0.1
Torreón	12	0.4	<0.1	0.2
Tuxtla Gutiérrez[a]				
Veracruz[a]				

[a] Blanks indicate stations temporarily shut down.

5. Pan American Air Sampling Program March 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by five countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Amercias in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed by the Radiation Surveillance Network (article 1, page 333).

The March 1965 air monitoring results from the five participating countries are given in table 5.

Table 5. Gross beta activity in air, PAHO, March 1965

Sampling stations	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average[a]
Kingston, Jamaica	17	0.28	<0.10	<0.15
Caracas, Venezuela	23	0.14	<0.10	<0.10
Lima, Peru	19	0.10	<0.10	<0.10
Santiago, Chile	31	0.13	<0.10	<0.10
Trinidad, West Indies	18	0.20	<0.10	<0.12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

6. Gross beta activity in air, North America March 1965

From January 1963 through November 1964, monthly average concentrations of airborne gross beta activity in Canada and the United States were presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*16*).

With the formation of the Mexican Air Monitoring Program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*17*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

In recent months, airborne gross beta activities have declined to such low levels that isogram comparisons are no longer meaningful. Before comparison with each other, the data from different networks must be multiplied by appropriate intercalibration factors. For example, if the Canadian data are considered as unity, the RSN and Pan American data must be multiplied by the intercalibration factor, 1.28, and the Mexican data must be multiplied by 0.81.

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FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR—80th MERIDIAN AND U.S. LOCATIONS, DECEMBER 1964[1]

Health and Safety Laboratory, Atomic Energy Commission

Since January 1, 1963, surface air filter samples have been collected as part of the HASL (Health and Safety Laboratory) 80th Meridian Network (figure 1). This network consists of fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile. An additional station at Mauna Loa, Hawaii, is included for comparison of data with the Chacaltaya, Bolivia station. These stations are both at high elevations and are at approximately equal north and south latitudes, respectively.

In August 1963, six additional air sampling stations were added to the HASL Network in North America (*1*). As with the original 80th Meridian Network sampling stations, both air filter and deposition samples are collected. Where surface air data are reported on a monthly basis, the deposition data are reported quarterly.

Sampling and analytical procedures

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters continuously at the rate of about 1,400 cubic meters per day. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count over the energy range, 0–3 Mev, is made approximately two weeks after the end of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal. The filters are then composited on a monthly basis and analyzed radiochemically, together with monthly ground deposition samples taken at the same site, for detectable fission and neutron activation products.

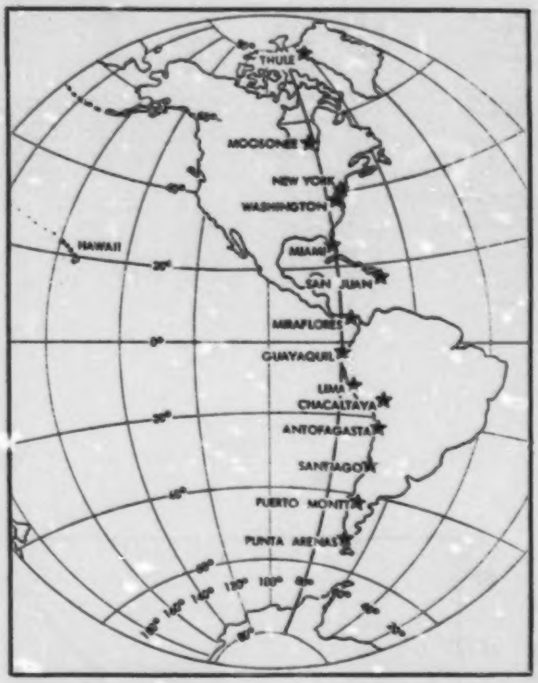

Figure 1. 80th Meridian Network sampling stations

Results and discussion

The total gamma activity concentrations in weekly ground level air samples collected during December 1964 by the HASL Ground Level Air Sampling Program are presented in table 1. The average monthly concentrations, weighted by the volume of air sampled during each week, are given in column six. These results are plotted in figure 2 as an activity latitude profile. The Amundsen-Scott South Pole station has been added to the list of sampling sites. This station, maintained by the U.S. Weather Bureau, collects daily samples on 2.5-inch diameter filter paper. These filters are composited on a monthly basis and assayed on an 8 x 4-inch NaI (Tl) crystal. For comparison, the latitude profiles of November 1964 and December 1963 are plotted in figures 3 and 4.

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[1] This report was developed from information and data in the April 1965 monthly report entitled "80th Meridian Network, Results of Air Sampling Measurements." These reports are furnished by the Health and Safety Laboratory, AEC, New York, N.Y. 10014.

Table 1. Radioactivity of surface air, December 1964

Sampling site	Gamma activity in photons /min.m³				
	1–8	8–15	15–22	22–1/1/65	Average
Thule	0.227	0.241	0.172	0.152	0.192
Moosonee	0.114	0.091	0.144	0.114	0.116
New York	0.153	0.140	0.187	0.133	0.152
Washington	0.195	0.133	0.153	0.104	0.142
Miami	0.272	0.246	0.277	0.235	0.255
Mauna Loa	0.0902	0.0455	No sample	0.0820	0.0737
San Juan	0.108	0.128	0.155	0.159	0.139
Miraflores	0.0470	0.0809	0.0886	0.117	0.0866
Guayaquil	0.0476	0.0702	0.0658	0.0468	0.0553
Lima	0.156	0.0658	0.251	0.0851	0.136
Chacaltaya	0.0404	0.023	0.0812	0.0236	0.0404
Antofagasta	0.101	0.0796	0.100	0.0612	0.0853
Santiago	0.0863	0.0908	0.0852	0.0603	0.0787
Puerto Montt	0.0653	0.0295	0.0616	0.0677	0.0522
Punta Arenas	0.0300	0.0366	0.0732	0.0564	0.0505
South Pole					0.0452
Additional U.S. sites:					
Westwood	0.135	0.177	0.182	0.148	0.143
Chattanooga	0.210	0.155	0.149	0.0943	0.150
Appleton	0.160	0.099	0.166	0.164	0.148
Midwest City	0.160	0.226	0.249	0.191	0.207
Palo Alto	0.182	0.135	0.141	0.056	0.120
Seattle	0.0552	0.0814	0.202	0.103	0.109

The December 1964 profile in the Northern Hemisphere follows the pattern of the December 1963 profile almost exactly, but at much lower concentrations. This indicates that the general structure of these profiles is meteorologically significant, being perpetuated from year to year. The November 1964 profile has higher concentrations than the December 1964 profile; its peak at Appleton (44°15′N) is more pronounced, and there is a slight northward shift of the second peak to Chattanooga (35°03′N). These effects may be the result of the debris from the October 16, 1964 Chinese test which was evident in November 1964 samples, but absent in the December 1964 samples. There are other meteorological parameters operative, however, since the concentration at Miraflores was higher in December than in November, and this difference cannot be attributed to the presence of Chinese debris.

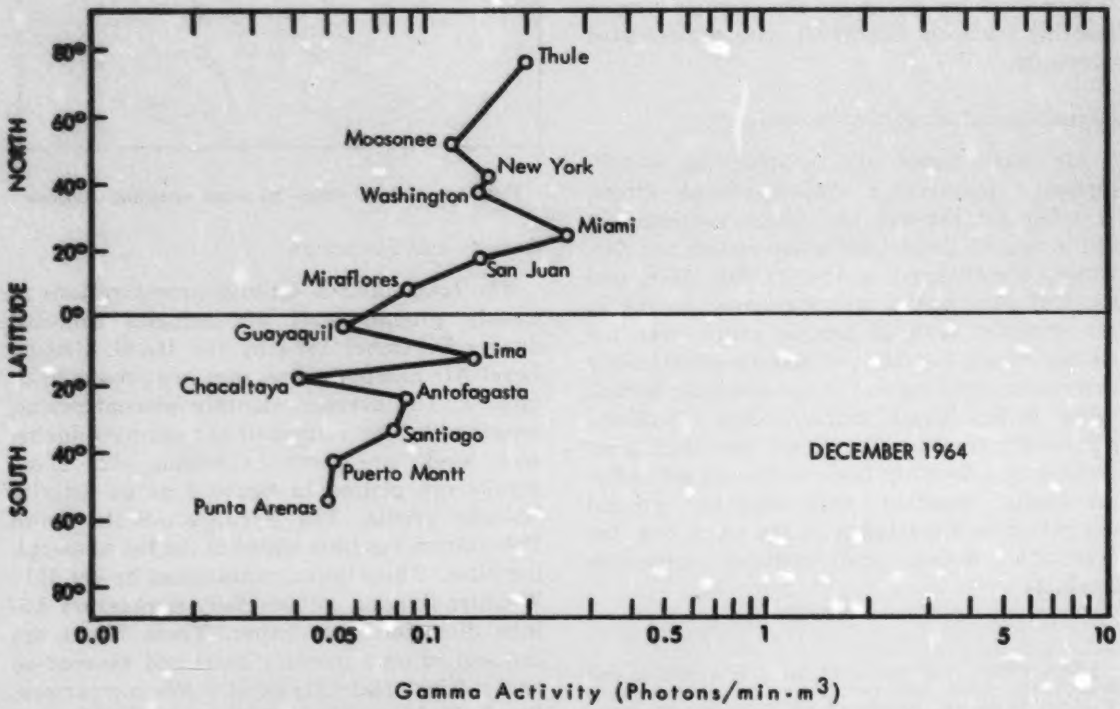

Figure 2. Profile of surface air gamma activity, 80th Meridian stations, December 1964

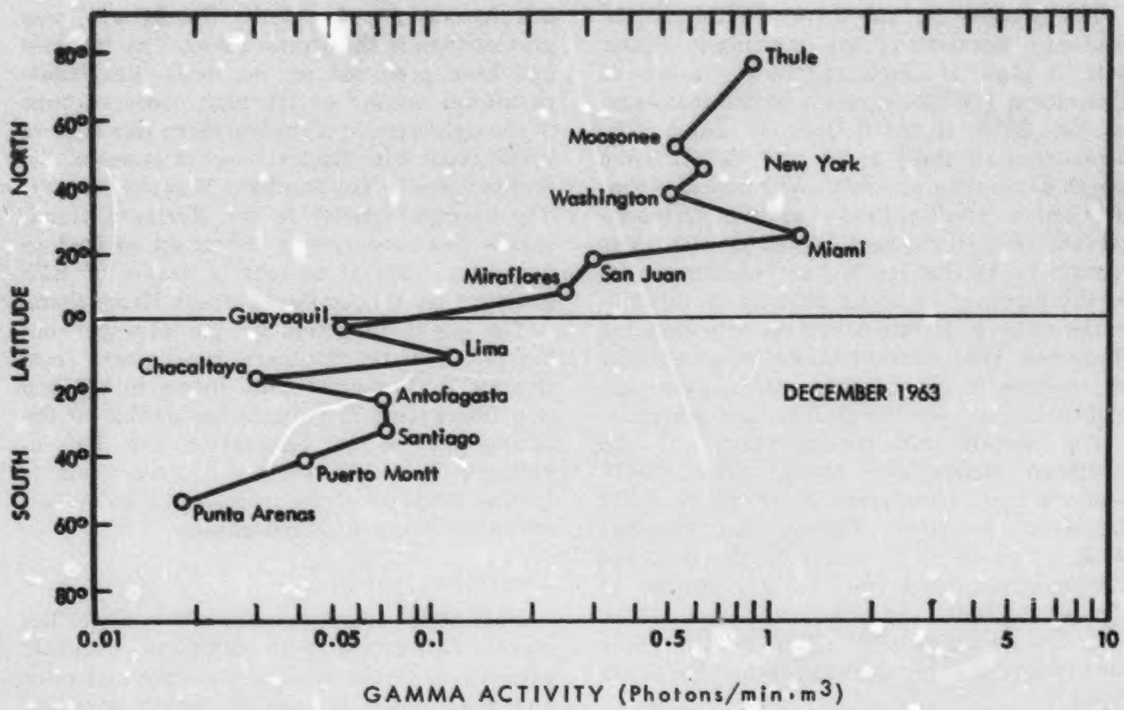

Figure 3. Profile of surface air gamma activity, 80th Meridian stations, December 1963

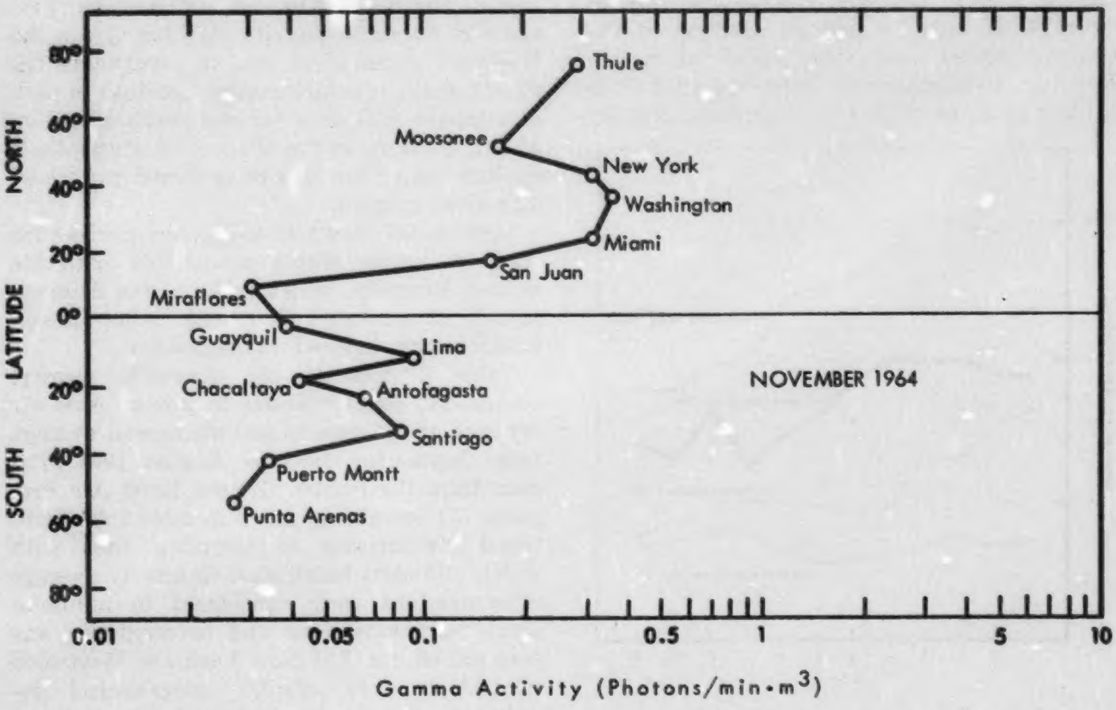

Figure 4. Profile of surface air gamma activity, 80th Meridian stations, November 1964

The profiles for all three months in the Southern Hemisphere are strikingly similar with a peak at Lima (12°06′S), a low at Chacaltaya (16°21′S), and a second maximum in the 23°S to 34°S latitude band. The persistence of these peaks and valleys from month to month and year to year indicates that they are the result of local or zonal meteorological conditions. It has been suggested in previous reports (*2, 3*) that the low at Chacaltaya may be the result of the high altitude of this collection site. It is interesting to note that the December 1964 concentrations at practically all stations in the Southern Hemisphere are higher than in the other profiles represented.

The weekly air concentrations in the Northern Hemisphere ranged from 0.0470 $\gamma/\text{min}\cdot\text{m}^3$ at Miraflores, P. C. Z. to 0.277 $\gamma/\text{min}\cdot\text{m}^3$ at Miami, Florida and averaged 0.152 $\gamma/\text{min}\cdot\text{m}^3$. The values in the Southern Hemisphere ranged from 0.023 $\gamma/\text{min}\cdot\text{m}^3$ at Chacaltaya, Bolivia to 0.251 $\gamma/\text{min}\cdot\text{m}^3$ at Lima, Peru and averaged 0.067 $\gamma/\text{min}\cdot\text{m}^3$ (including the average monthly concentration at the South Pole).

A comparative plot of the monthly average concentrations for the Northern and Southern Hemispheres in 1963 and 1964 is presented in figure 5. It appears that all vestiges of the Chinese debris had disappeared from the Northern Hemisphere by December 1964. It is evident in figure 5 that in December 1964 the activity of the Southern Hemisphere was greater than in the previous year. This increase had been predicted on the basis that trans-equatorial mixing of the high concentrations in the stratosphere of the Northern Hemisphere would occur with the low concentrations of the stratosphere in the Southern Hemisphere (*3*). The average activity in the Northern Hemisphere has concurrently decreased so that in December 1964 it is only a factor of 2.25 greater than that of the Southern Hemisphere.

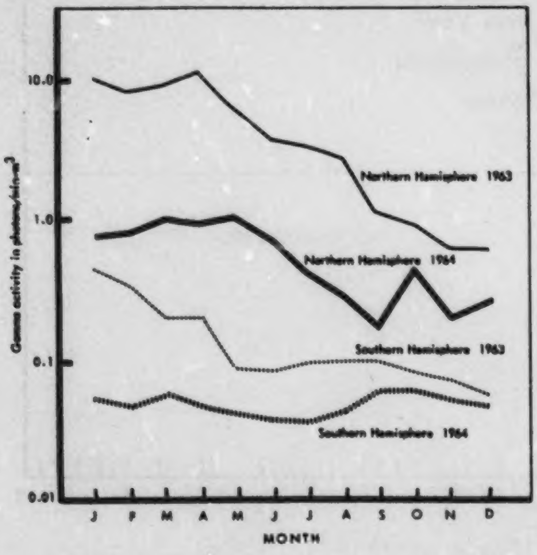

Figure 5. Average hemispheric gamma activity concentrations for 1963 and 1964

The slight reduction of the average concentration in the Southern Hemisphere from October to November 1964 shown in figure 5 was interpreted to indicate the decline of the spring peak in that hemisphere (*4*). The increase in December reversed that trend, and is further evidence of the increasing rate of fallout in the Southern Hemisphere.

Longitudinal effects

Most of the sampling sites of the Naval Research Laboratory 80th Meridian Program extended along the west coast of South America and along the east coast of North America. In August 1964 six additional sites within the continental United States were instituted as part of the HASL Surface Air Sampling Program to afford better latitude coverage in the Northern Hemisphere and to investigate the effects of the opposite coastal locations in each hemisphere. The data for one year's operation of this network in the absence of atmospheric nuclear testing can now be reviewed with these objectives in mind.

Cesium-137 was selected as the nuclide for study to permit direct comparison with the British Program, which included the determination of cesium-137 among other fission products and induced radionuclides.

Table 2 presents the quarterly average cesium-137 concentrations in ground level air for each of the seasons and the annual average from September 1963 to August 1964. The data from the British Ground Level Air Program (*5*) are also included in table 2 for additional comparisons of sampling sites with widely different longitudes. Quarterly average concentrations were considered to minimize short term variations and to maximize any seasonal effects. The New York and Westwood sites have very similar geographical coordinates, and can be considered essentially as duplicate stations. The agreement of the data from these two stations in table 2 attests to the good precision of replicate collections and analyses. The data from the New York and Westwood stations are averaged and plotted as a single point in subsequent figures.

The average quarterly cesium-137 concentrations are grouped in longitude bands and are plotted as a function of latitude for each of the four seasons in figures 6 through 9. In each figure, a line is drawn through the points in the 65°W to 89°W longitude band within which all of the original 80th Meridian stations fall, plus three of the six stations which were initiated in August 1963. Figure 6 illustrates that the 1963 fall latitude profile in the Northern Hemisphere was virtually the same for all longitudes. It would be desirable to compare cesium-137 concentrations at stations of different longitudes in the Southern Hemisphere also. Unfortunately, there are no suitable data available for comparison at the present time. The profiles in the Southern Hemisphere are presented in figures 6 through

Table 2. ^{137}Cs concentrations in ground level air, September 1963–August 1964

Sampling site	Latitude	Longitude	^{137}Cs dpm/100 m^3 9/63–11/63	12/63–2/64	3/64–5/64	6/64–8/64	Annual avg. 9/63–8/64
Thule	76°36′N	68°35′W	6.3	7.2	13	11	9.4
Lerwick *	60° N	01° W	5.7	9.8	14	9.2	9.7
Eskdalemuir *	55° N	03° W	8.2	5.7	8.4	6.2	7.1
Orfordness *	52° N	01°30′E	8.0	8.1	12	11	9.8
Chilton *	51°30′N	01° W	6.5	7.3	12	9.2	8.8
Milford Haven *	51°30′N	05° W	7.6	7.1	11	11	9.2
Moosonee	51°16′N	80°39′W	6.3	6.4	12	10	8.7
Seattle	47°36′N	122°20′W	5.4	5.7	9.9	4.3	6.3
Appleton	44°15′N	88°25′W	9.0	6.7	17	14	12
Westwood	41°00′N	74°01′W	12	6.9	17	13	12
New York	40°48′N	73°58′W	14	7.2	15	13	12
Sterling	38°58′N	77°25′W	10	6.5	15	12	11
Palo Alto	37°30′N	122°23′W	9.7	10	16	5.6	10
Midwest City	35°25′N	97°30′W	12	12	15	9.0	12
Chattanooga	35°03′N	85°20′W	12	8.4	19	13	13
Miami	25°49′N	80°17′W	8.4	12	16	5.6	10
Hong Kong *	22°30′N	144° E	7.1	7.1	8.7	2.0	6.2
Mauna Loa	19°28′N	155°36′W	3.3	8.5	11	5.0	7.0
San Juan	18°26′N	66°00′W	2.7	5.0	12	6.5	6.6
Miraflores	9°00′N	79°35′W	0.92	4.0	7.8	1.0	3.4
Guayaquil	2°10′N	79°52′W	0.61	0.68	1.2	0.47	0.74
Lima	12°06′S	77°01′W	1.3	1.4	0.77	1.1	1.1
Chacaltaya	16°21′S	68°07′W	0.84	0.29	0.37	1.1	0.65
Antofagasta	23°37′S	70°16′W	1.3	0.93	0.80	1.9	1.2
Santiago	33°27′S	70°42′W	1.4	1.2	0.81	1.2	1.2
Puerto Montt	41°27′S	72°57′W	0.46	0.87	0.59	0.51	0.61
Punta Arenas	53°08′S	70°53′W	0.32	0.35	0.36	0.44	0.37

* United Kingdom ground level air stations

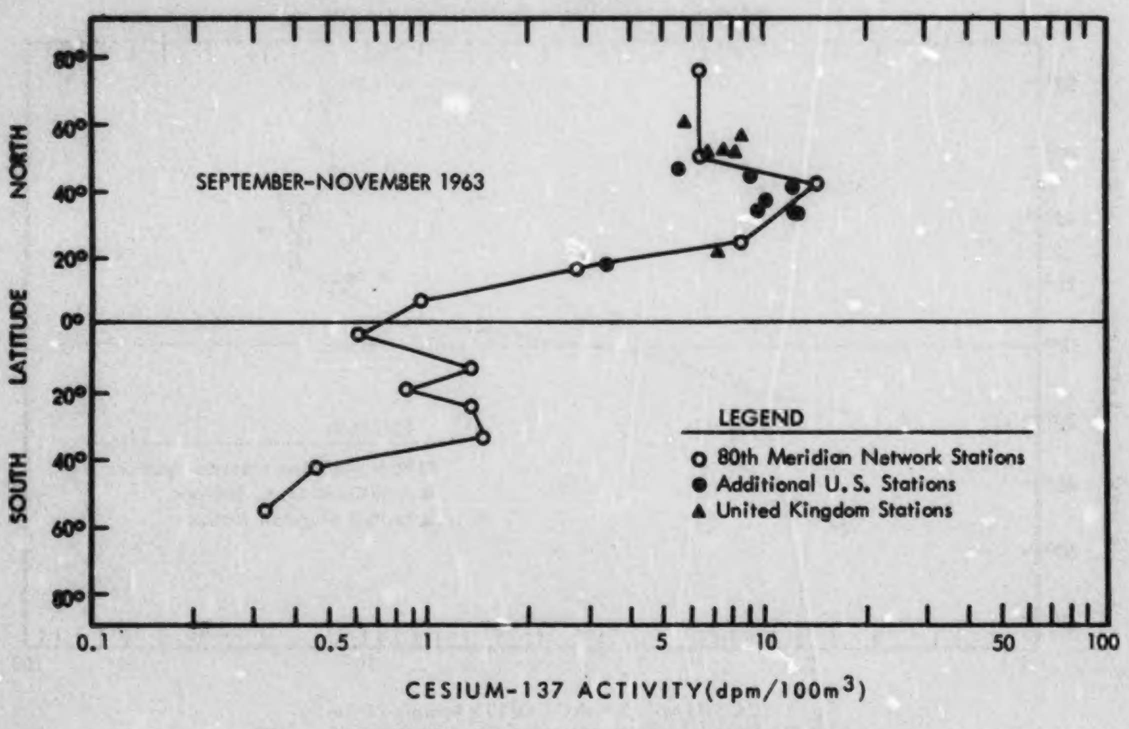

Figure 6. Profile of cesium-137 air activity, 80th Meridian and selected stations, September–November 1963

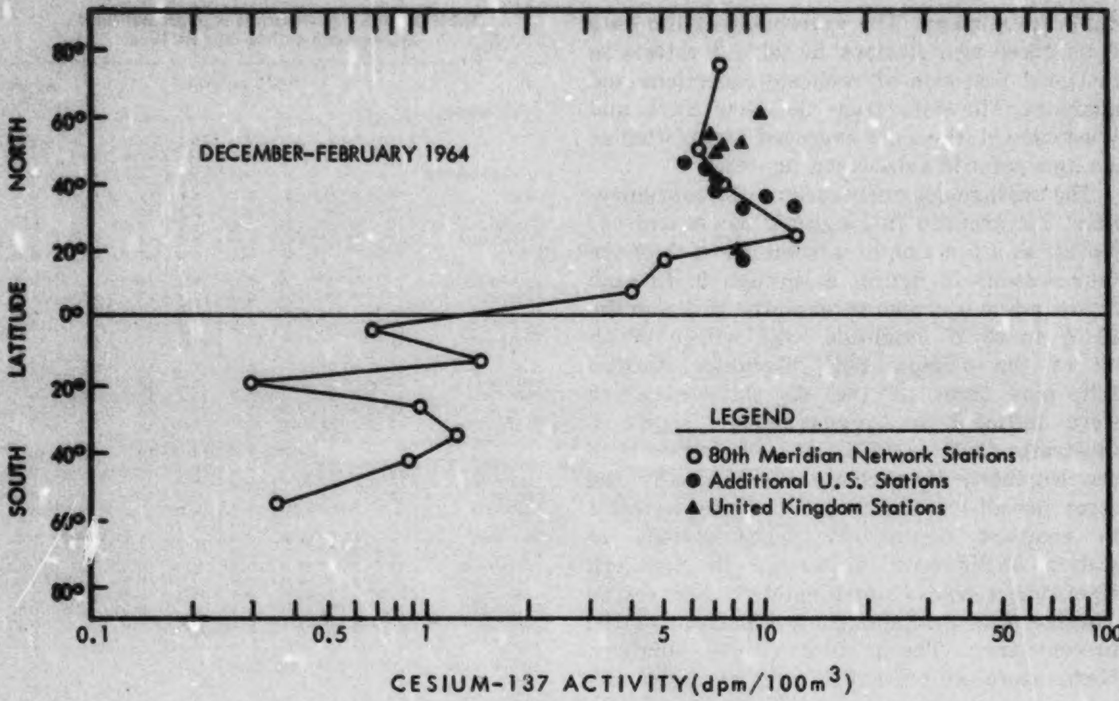

Figure 7. Profile of cesium-137 air activity, 80th Meridian and selected stations, December 1963–February 1964

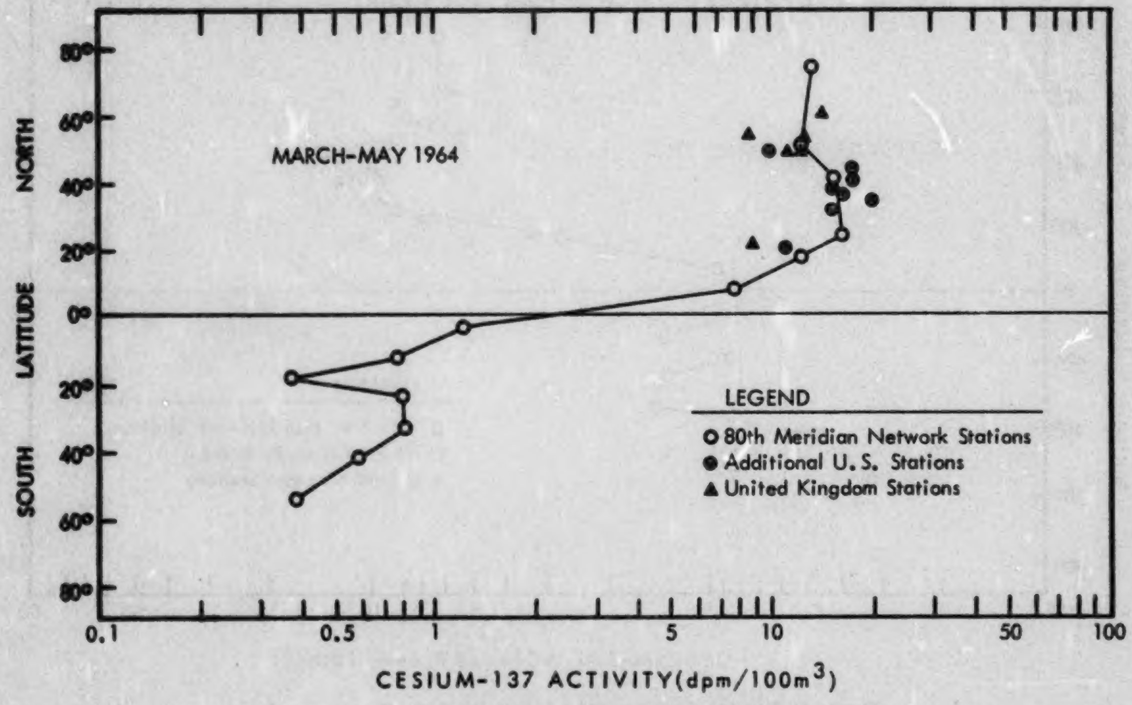

Figure 8. Profile of cesium-137 air activity, 80th Meridian and selected stations, March–May 1964

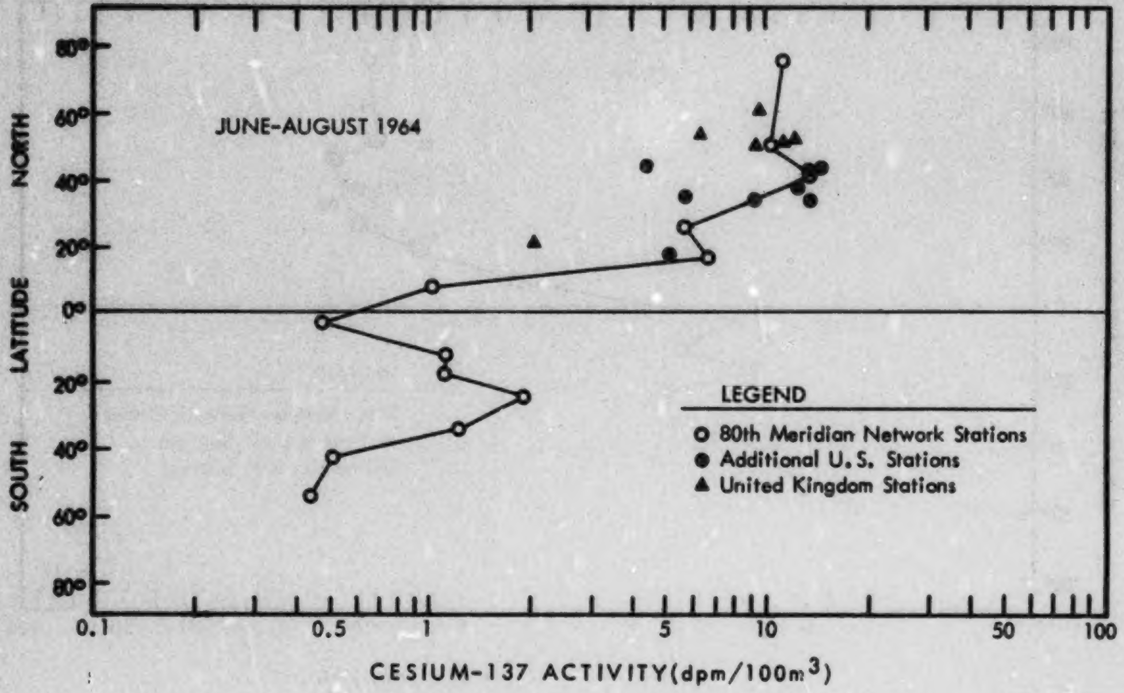

Figure 9. Profile of cesium-137 air activity, 80th Meridian and selected stations, June-August 1964

9 to illustrate the disparity of concentrations between hemispheres, and to indicate the lack of a common profile in the Southern Hemisphere although such a common profile exists in the Northern Hemisphere along the 80th Meridian. The same pattern of a single profile in the Northern Hemisphere persists during the 1964 winter and spring (figures 7 and 8), although there is a greater variation of individual points from the line in these seasons than in the preceding fall. Figure 9 shows that the greatest divergence of the stations at other longitudes from the profile of 65°W to 89°W band occurs in the summer of 1964.

These seasonal variations tend to compensate each other when yearly averages are considered. The annual average cesium-137 concentrations for the period September 1963 to August 1964 are plotted in figure 10, and a return to a single latitude profile for all longitudes in the Northern Hemisphere is obtained. There are no serious coastal effects since the one profile generally describes the concentrations on the east coast of China, the east and west coasts of the United States and in the British Isles. The values for Eskdalemuir (55°N), Seattle (47°36′N) and Hong Kong (22°30′N) are slightly below the curve in figure 10, but these concentrations are clearly representative of the Northern Hemispheric latitudes, being a factor of at least five greater than the highest concentration in the Southern Hemisphere. Presumably local meteorological conditions are the predominate factor in these stations being somewhat low and in the seasonal variations described earlier.

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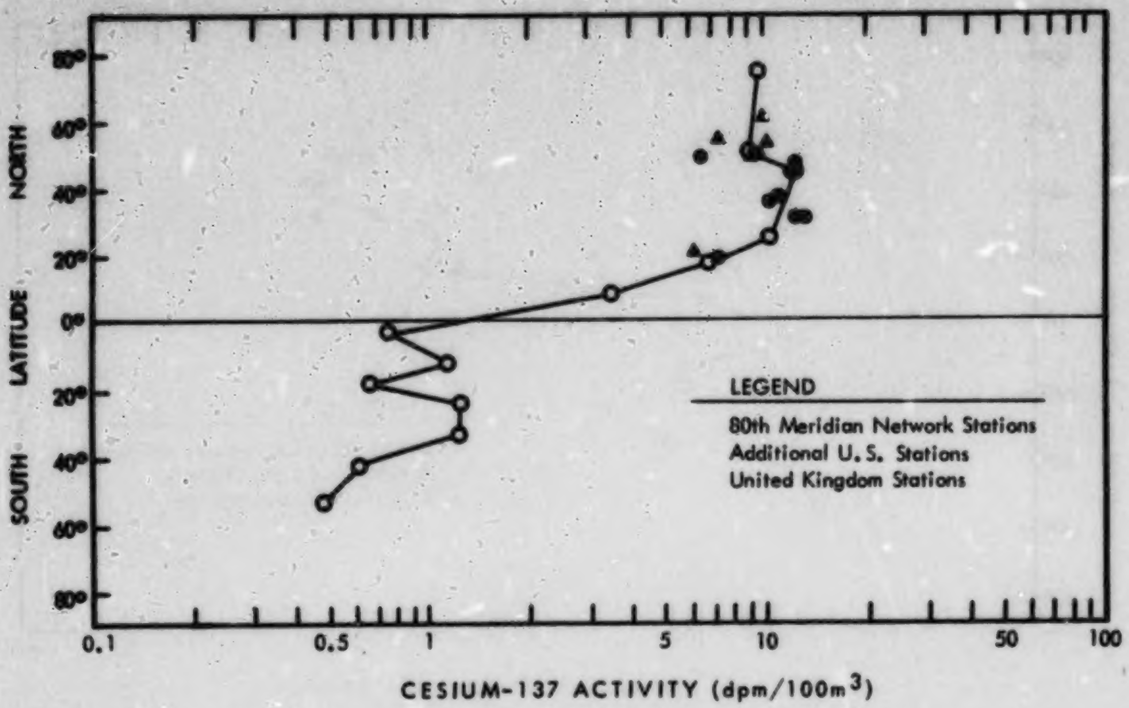

Figure 10. Profile of annual average cesium-137 air activity, 80th Meridian stations, September 1963–August 1964

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
March 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two con-

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

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secutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Table 1. Analytical errors associated with estimated concentrations for selected radionuclides in milk

Nuclide	Estimated concentration (pCi/liter)	Error * (pCi/liter)	Estimated concentration (pCi/liter)	Error * (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

* Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for the first quarter of 1965 and the month of March 1965 (actual reporting period is February 28—March 27). The radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similiar procedure is used for the network average.

The quantitative distribution of the number of sampling locations, by ranges of strontium-90 and cesium-137 concentrations in milk for the last 6 months are compared in tables 3 and 4. These tables also provide comparable data for March 1964.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

For special purposes of comparison and reference, the network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960—March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*). An annual summary for 1964 appeared in the April 1965 RHD (*3*).

Discussion of Data

Neither iodine-131 nor barium-140 was detected in the PMN samples during March 1965. Iodine-131 has not been detected in PMN milk samples since November 30, 1964. During

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[2] The conversion factor is 1.18×10^{-3} g K/pCi ^{40}K.

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, March 1965 and the first quarter 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month
Ala:	Montgomery	1.19	1.18	<5	<5	19	18	55	60
Alaska:	Palmer	1.18	1.19	<5	<5	17	18	60	60
Ariz:	Phoenix	1.20	1.21	<5	<5	6	5	25	25
Ark:	Little Rock	1.16	1.18	<5	<5	34	37	70	75
Calif:	Sacramento	1.26	1.27	<5	<5	7	8	35	30
	San Francisco	1.27	1.28	<5	<5	8	12	35	40
C. Z:	Cristobal	1.14	1.12	<5	<5	5	4	40	35
Colo:	Denver	1.27	1.28	<5	<5	18	18	70	90
Conn:	Hartford	1.12	1.12	<5	<5	16	16	[illegible]	95
Del:	Wilmington	1.15	1.14	<5	<5	19	20	[illegible]	80
D. C:	Washington	1.17	1.19	<5	<5	17	16	60	65
Fla:	Tampa	1.18	1.17	<5	<5	13	13	160	165
Ga:	Atlanta	1.19	1.16	<5	<5	28	28	90	95
Hawaii:	Honolulu	1.18	1.18	<5	<5	11	10	65	[illegible]
Idaho:	Idaho Falls	1.21	1.26	<5	<5	21	21	110	110
Ill:	Chicago	1.12	1.12	<5	<5	17	18	90	95
Ind:	Indianapolis	1.19	1.18	<5	<5	17	18	75	75
Iowa:	Des Moines	1.20	1.25	<5	<5	22	21	60	60
Kans:	Wichita	1.24	1.25	<5	<5	18	18	55	55
Ky:	Louisville	1.17	1.16	<5	<5	22	22	60	60
La:	New Orleans	1.23	1.22	5	10	43	44	80	100
Maine:	Portland	1.14	1.14	<5	<5	22	22	135	125
Md:	Baltimore	1.16	1.13	<5	<5	18	18	65	70
Mass:	Boston	1.16	1.16	<5	<5	23	24	140	145
Mich:	Detroit	1.15	1.14	<5	<5	16	16	85	90
	Grand Rapids	1.18	1.19	<5	<5	19	20	90	100
Minn:	Minneapolis	1.22	1.27	<5	<5	26	25	90	95
Miss:	Jackson	1.25	1.24	<5	<5	34	28	60	70
Mo:	Kansas City	1.22	1.24	<5	<5	22	26	60	60
	St. Louis	1.25	1.28	<5	<5	17	16	50	55
Mont:	Helena	1.25	1.29	<5	<5	18	18	95	100
Nebr:	Omaha	1.25	1.26	<5	<5	18	19	50	55
Nev:	Las Vegas	1.20	1.23	<5	<5	9	8	40	40
N. H:	Manchester	1.16	1.16	<5	<5	24	23	155	150
N. J:	Trenton	1.13	1.15	<5	<5	16	16	80	80
N. Mex:	Albuquerque	1.22	1.23	<5	<5	12	10	45	50
N. Y:	Buffalo	1.11	1.10	<5	<5	17	17	110	110
	New York	1.12	1.14	<5	<5	19	21	105	100
	Syracuse	1.11	1.15	<5	<5	16	16	95	95
N. C:	Charlotte	1.20	1.16	<5	<5	29	29	65	65
N. Dak:	Minot	1.21	1.24	<5	<5	52	53	125	120
Ohio:	Cincinnati	1.16	1.16	<5	<5	17	17	70	70
	Cleveland	1.16	1.17	<5	<5	18	18	95	100
Okla:	Oklahoma City	1.18	1.14	<5	<5	21	26	55	55
Ore:	Portland	1.28	1.28	<5	<5	20	23	100	100
Pa:	Philadelphia	1.16	1.16	<5	<5	17	17	80	80
	Pittsburgh	1.16	1.15	<5	<5	24	24	105	110
P. R:	San Juan	1.14	1.12	<5	<5	12	11	50	45
R. I:	Providence	1.16	1.15	<5	<5	19	18	100	95
S. C:	Charleston	1.20	1.20	<5	<5	30	32	85	90
S. Dak:	Rapid City	1.08	1.08	<5	<5	28	31	135	130
Tenn:	Chattanooga	1.22	1.21	<5	<5	31	30	70	70
	Memphis	1.20	1.18	<5	<5	26	26	45	45
Tex:	Austin	1.15	1.15	<5	<5	9	9	35	35
	Dallas	1.19	1.21	<5	<5	18	19	45	45
Utah:	Salt Lake City	1.30	1.35	<5	<5	25	22	125	125
Vt:	Burlington	1.12	1.14	<5	<5	21	23	120	125
Va:	Norfolk	1.19	1.18	<5	<5	21	22	60	60
Wash:	Seattle	1.26	1.26	<5	<5	23	20	90	90
	Spokane	1.28	1.30	<5	<5	26	32	100	95
W. Va:	Charleston	1.18	1.18	<5	<5	16	17	50	50
Wis:	Milwaukee	1.20	1.21	<5	<5	14	15	100	105
Wyo:	Laramie	1.25	1.22	<5	<5	13	11	65	60
Network average		1.19	1.19	<5	<5	19.9	20.4	79	81

[a] Results of barium-140 and iodine-131 analyses all zero.

Table 3. Ranges of station monthly averages for strontium-90, October–December 1964, January–March 1965 and March 1964

Range, pCi/liter	Number of stations in range						
	1964			1965			1964
	Oct.	Nov.	Dec.	Jan.	Feb.	March	March
Under 10	6	6	8	6	3	5	2
10–19	37	31	29	32	31	29	17
20–29	13	19	20	19	22	21	30
30–39	7	6	4	4	5	6	10
40–49	0	1	2	1	2	1	2
50–59	0	0	0	1	0	1	1
60–69	0	0	0	0	0	0	1

Table 4. Ranges of station monthly averages for cesium-137, October–December 1964, January–March 1965 and March 1964

Range, pCi/liter	Number of stations in range						
	1964			1965			1964
	Oct.	Nov.	Dec.	Jan.	Feb.	March	March
Under 50	16	15	9	11	8	9	2
50–99	40	41	38	38	38	36	11
100–149	6	4	14	12	15	16	22
150–199	0	2	2	2	2	2	20
200–249	1	1	0	0	0	0	6
250–299	0	0	0	0	0	0	2

the period of October 26, 1964, through November 30, 1964, iodine-131 was detected in 45 samples and was attributed to the detonation of a nuclear device by the Communist Chinese on October 16, 1964.

Slight increases in the March strontium-90 monthly averages were observed for 26 stations while levels at 20 stations decreased slightly from the previous month. The network average of 63 stations for March 1965 was 20.4 pCi/liter compared to 20.2 pCi/liter in February. The network average for March 1965 was 20 percent lower than March 1964. The ratio of the highest concentration to the average concentration was 2.60 for March 1965 compared to 2.64 for March 1964.

Slight increases in the March cesium-137 monthly averages were observed for 27 stations while levels at 21 stations decreased slightly from the previous month. The network average of 63 stations for March 1965 was 81 pCi/liter compared to 80 pCi/liter in February. The network average was 40 percent lower for March 1965 than March 1964. The ratio of the highest concentration to the average concentration was 2.04 for March 1965 compared to 1.91 for March 1964.

Since the March network averages for both strontium-90 and cesium-137 are lower this year than last and the ratios of maximum concentration to average concentration remained essentially constant, a continued decrease in radionuclide concentrations in milk should be observed provided fresh fission debris is not introduced into the atmosphere.

Neither strontium-90 nor cesium-137 have exhibited a "spring rise" during February and March 1965. To further support this, the number of stations reporting increased levels over the previous month was approximately equal to the number of stations reporting decreased levels over the previous month for both radionuclides.

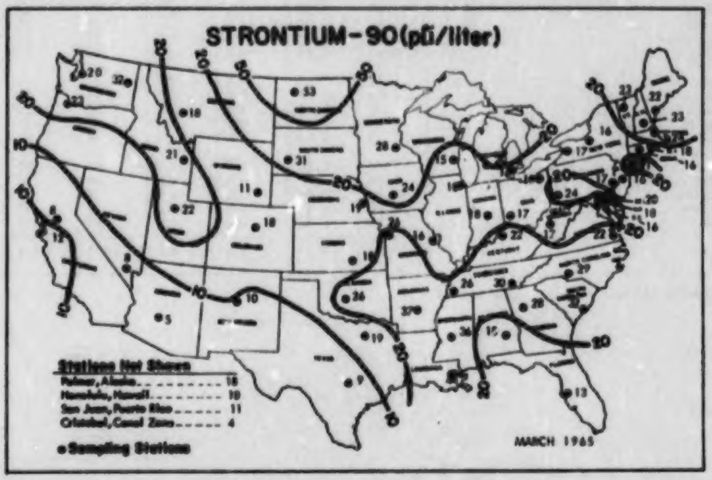

Figure 1. Strontium-90 concentrations in pasteurized milk, March 1965

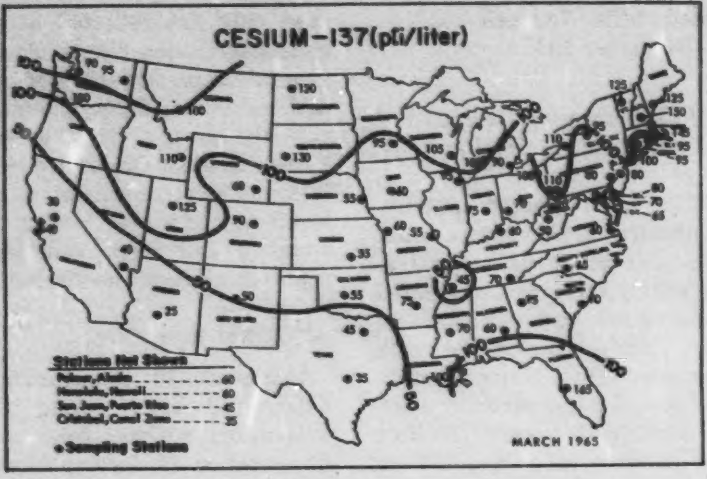
CESIUM-137(pCi/liter)
Stations Not Shown
Palmer, Alaska ---------- 60
Honolulu, Hawaii ---------- 60
San Juan, Puerto Rico ------- 45
Cristobal, Canal Zone ------- 35
● Sampling Stations
MARCH 1965

Figure 2. Cesium-137 concentrations in pasteurized milk, March 1965

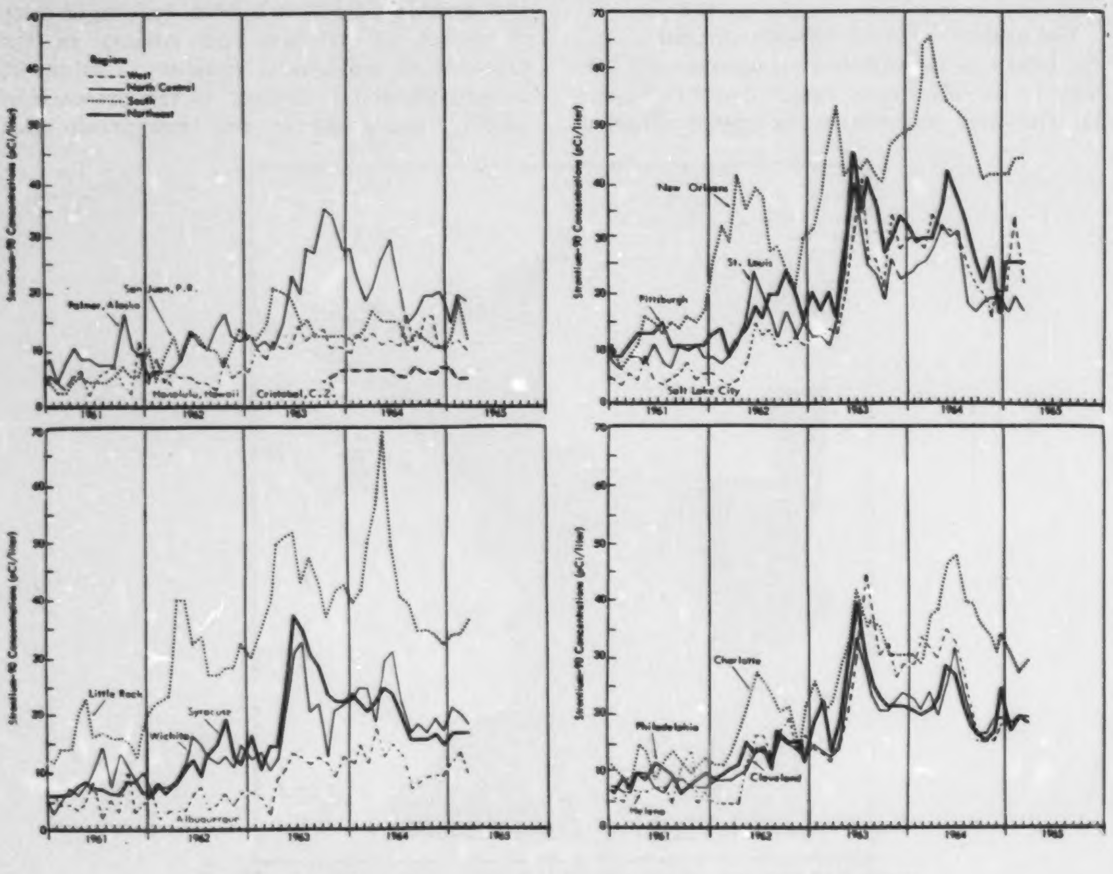

Figure 3. Strontium-90 concentrations in pasteurized milk, 1961-March 1965

2. Minnesota Milk Network
July–December 1964

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium–90 concentrations. At present, monthly samples are collected for iodine–131, cesium–137, and strontium–90 analyses. Initially, daily two-ounce milk samples were composited into a single monthly sample which was analyzed for strontium–90. In October 1961, additional weekly one-liter grab samples were analyzed for iodine–131. In November 1962, strontium–90 analyses were reduced to a single monthly sample composited of weekly samples. This procedure was continued until August 1963 when the current procedure was initiated.

The present network consists of eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 4). One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. These samples are, in general, representative of milk marketed in each milkshed. These samples are customarily collected in the cities where the Minnesota Health District Offices are located. However, it is sometimes convenient to collect samples at locations other than where district offices are situated, but such samples are considered representative of the district concerned.

Analytical procedure

Strontium–90 concentrations in milk are determined after ashing (at 450° C) the evaporated residue from an 800-ml sample. Evaporation is accomplished by means of a steam bath and infrared overhead heating. Oxalates of calcium and strontium are precipitated at a pH of 4 from a nitric acid solution of the ash. The separated oxalates are then decomposed with nitric acid and peroxide. The resulting solution is then scavenged with chromates of yttrium and barium in the presence of ammonium chloride. Yttrium–90 is then allowed to ingrow in the presence of stable yttrium carrier and then precipitated

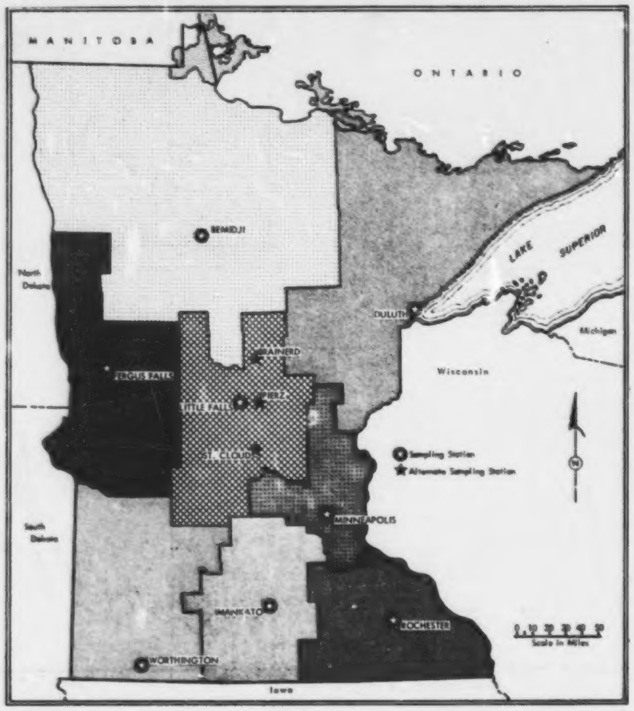
MANITOBA
ONTARIO
LAKE SUPERIOR
BEMIDJI
North Dakota
DULUTH
Michigan
BRAINERD
FERGUS FALLS
Wisconsin
PIERZ
LITTLE FALLS
ST. CLOUD
Sampling Station
Alternate Sampling Station
N
MINNEAPOLIS
South Dakota
MANKATO
ROCHESTER
0 10 20 30 40 50
Scale in Miles
WORTHINGTON
Iowa

Figure 4. Minnesota milk sampling locations

under the same conditions prevailing in the scavenging procedure. The yttrium precipitate is converted to the oxalate, filtered, and counted in a low-background anticoincidence counter.

Iodine–131 and cesium–137 concentrations are determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodine crystal detector and multichannel analyzer. Either a 3 x 3-inch crystal and 256-channel analyzer or a 4 x 4-inch crystal and 512-channel analyzer are used. The minimum detectable concentration of iodine–131 in milk is 10 pCi/liter.

Results

The monthly strontium–90, iodine–131, and cesium–137 concentrations in milk are given in table 5 for July through December 1964. These data as well as analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (4). The strontium–90, cesium–137, and iodine–131 concentrations in Minnesota pasteurized milk are presented graphically by milkshed in figure 5 for the period 1962-1964.

During 1964, iodine–131 was not detected in Minnesota milk until the first week in November, when levels in excess of 10 picocuries per liter were observed (table 6). Collections from each milkshed were immediately increased from one sample per month to one sample per week. The maximum concentration observed was 53 picocuries per liter in the early part of November. By the second week in December, only one of eight had a measurable iodine–131 concentration—18 pCi/liter was observed in the December 5 weekly sample from Worthington.

Previous coverage in *Radiological Health Data:*

Period	Issue
October–December 1961 (Iodine–131 data)	*March 1962*
May–December 1961 (Strontium–90 data)	*August 1962*
March–September 1962	*April 1963*
September 1962–June 1963	*November 1963*
July–December 1963	*June 1964*
January–June 1964	*January 1965*

Table 5. Radionuclides in Minnesota milk, July–December 1964 [a]
(Concentrations in pCi/liter)

Sampling location (District office)	Strontium-90						Cesium-137					
	July	Aug	Sept	Oct	Nov	Dec	July	Aug	Sept	Oct	Nov	Dec
Bemidji	54	35	43	33	41	38	330	220	185	170	170	190
Duluth	62	35	40	39	39	33	430	250	270	170	160	200
Fergus Falls	27	25	19	20	19	30	100	140	120	110	95	100
Little Falls	[b] 42	[c] 31	[c] 25	16	[c] 27	17	[b] 380	[c] 250	[c] 200	99	[c] 85	220
Mankato	20	17	17	22	15	12	230	110	100	60	55	85
Minneapolis	24	25	27	13	21	15	180	140	130	64	92	131
Rochester	22	17	18	19	18	13	150	92	85	63	64	90
Worthington	25	16	14	14	14	13	170	70	76	69	50	70
Averages	35	25	25	22	24	20	250	100	120	100	100	140

[a] Each monthly iodine-131 concentration at each station was below the minimum detectable concentration.
[b] Sample collected at Piers.
[c] Sample collected at Brainerd.

Table 6. Appearance of iodine-131 in Minnesota milk, November–December 1964
(Concentrations in pCi/liter)

Sampling location (District office)	November [a]																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Bemidji	----	34	----	----	----	----	----	----	37	----	----	----	----	----	----	<10	----	----	----	----	----	----	<10	
Duluth	----	53	----	----	----	----	19	----	----	----	----	----	24	----	----	----	----	----	----	----	17			
Fergus Falls	----	----	----	----	<10	----	----	----	<10	----	----	----	----	----	----	20	----	----	----	----	----	----	----	14
Little Falls	----	----	----	----	<10	----	----	----	<10	----	----	----	----	----	----	<10	----	----	----	----	----	----	14	
Mankato	----	----	<10	----	----	----	----	----	12	----	----	----	----	----	----	<10	----	----	----	----	<10			
Minneapolis	----	19	<10	----	----	----	----	19 [b] 24	----	----	----	----	----	----	----	----	----	----	----	----	----	----	26 [c] 19	
Rochester	----	----	22	----	----	----	----	----	15	----	----	----	----	----	----	<10	----	----	----	----	----	----	<10	
Worthington	----	----	----	<10	----	----	<10	----	----	----	----	----	----	<10	----	----	----	----	----	----	<10			

[a] After November 24, ^{131}I levels were below the detection limit.
[b] Composite Minneapolis—St. Paul sample.
[c] Check sample.

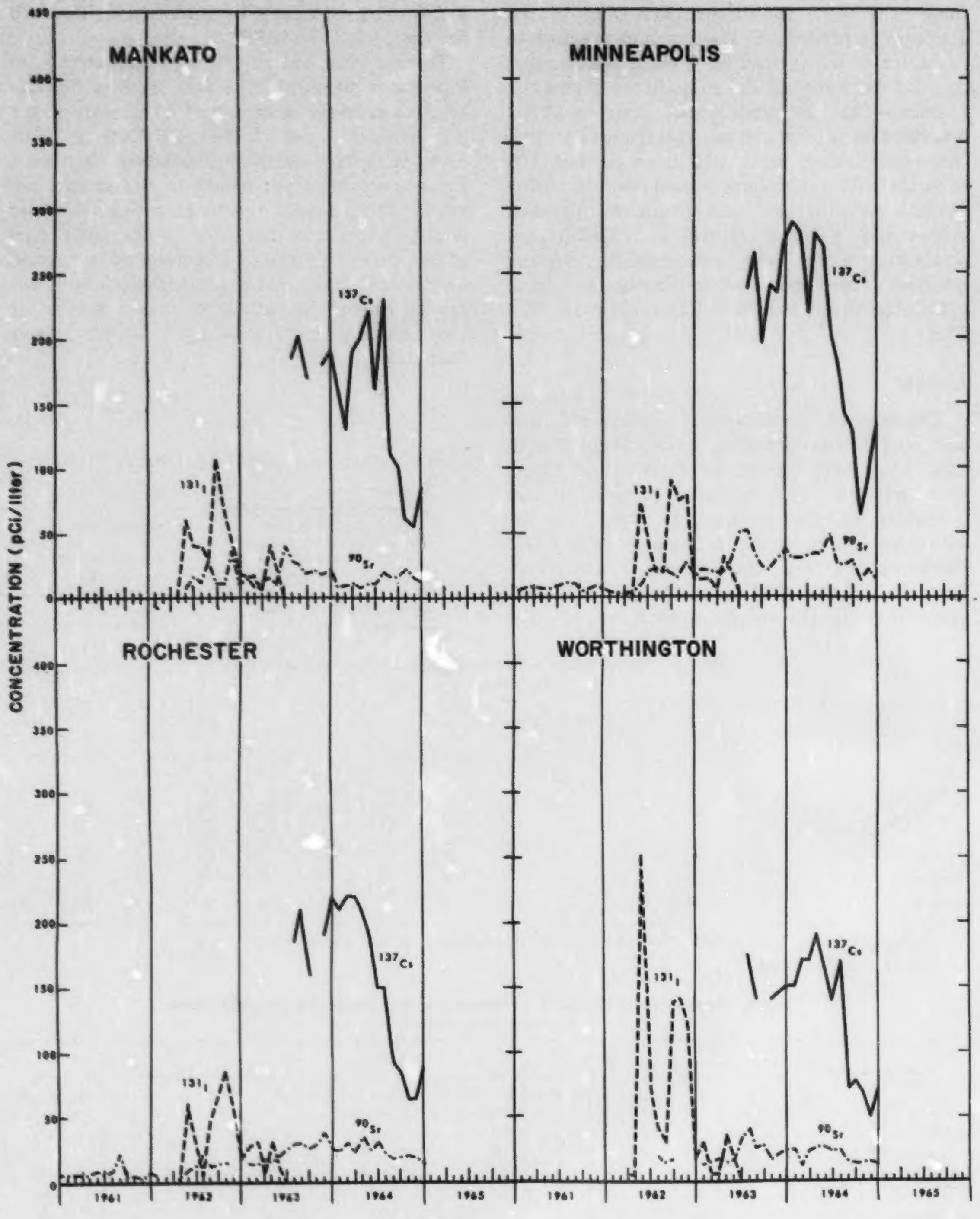

Figure 5. Radionuclide concentrations in Minnesota milk, 1961 to December 1964 (November 1964 iodine-131 data omitted—see table 6)

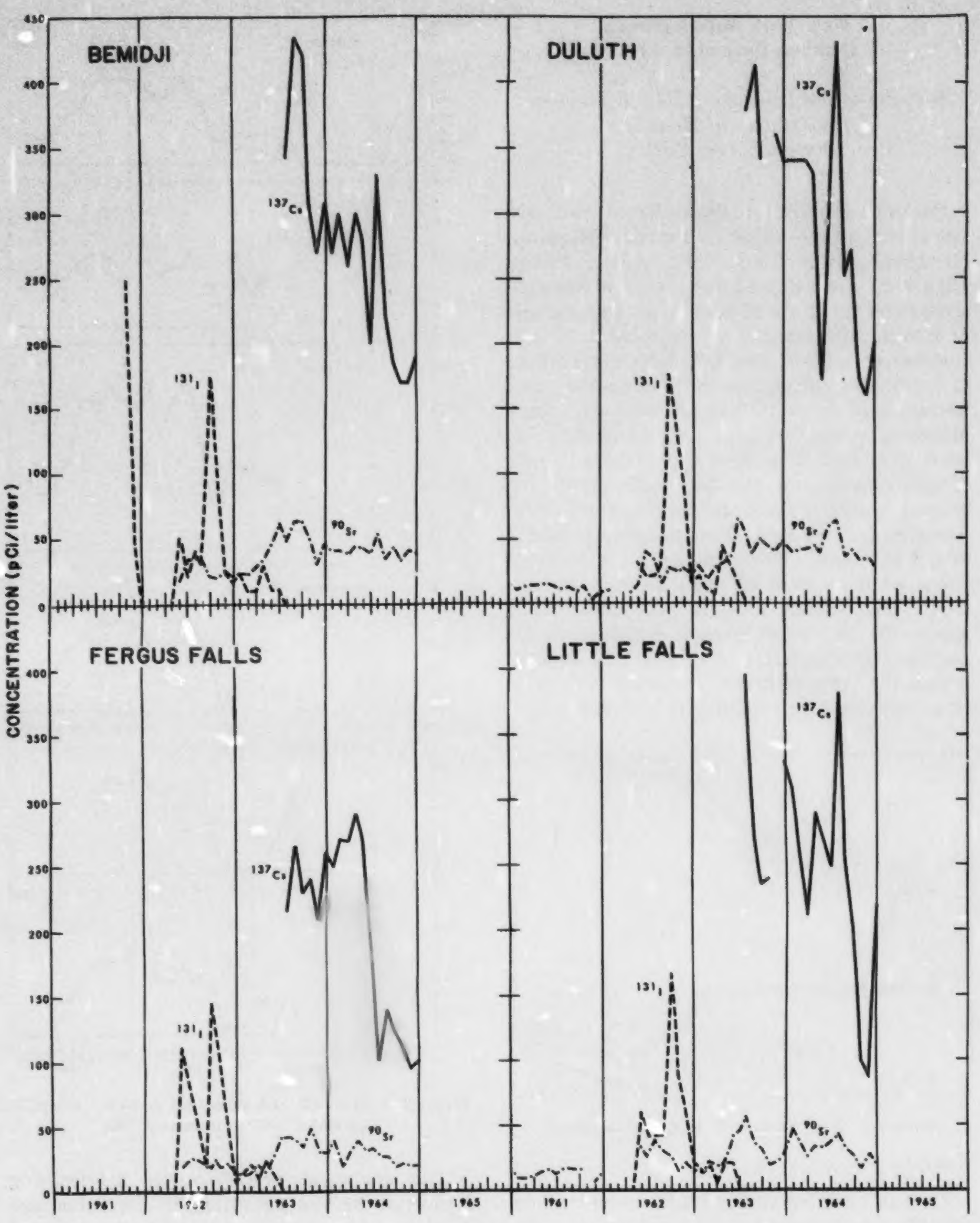

Figure 5. Radionuclide concentrations in Minnesota milk, 1961 to December 1964 (November 1964 iodine-131 data omitted—see table 6)—continued

30

3. New York Milk Network
October–December 1964

Division of Environmental Health Services
Department of Health,
State of New York

Pasteurized milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 6) are analyzed for their radionuclide content by the State of New York Department of Health. The samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 at all stations except Massena, where samples are composited biweekly, and at New York City, where a milk sample representing the total milk supply for one day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily composite is prepared from samples taken at a marketing point. The Albany samples are analyzed for iodine–131 and other gamma emitting radionuclides. In the event that any city reports iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

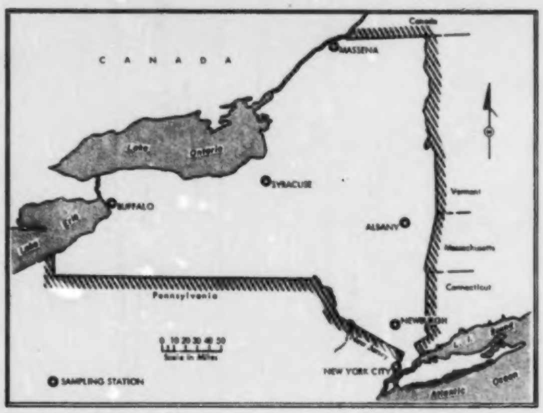
CANADA
MASSENA
Canada
Lake Ontario
SYRACUSE
BUFFALO
Lake Erie
ALBANY
Vermont
Massachusetts
Connecticut
Pennsylvania
NEWBURGH
0 10 20 30 40 50
Scale in Miles
NEW YORK CITY
L. I.
Sound
Atlantic Ocean
SAMPLING STATION

Figure 6. New York milk sampling locations

Analytical procedures

Gamma emitting radionuclide concentrations in milk are determined by scintillation spectrometry and the application of a matrix method of analysis to the resultant spectral data. (*5*)

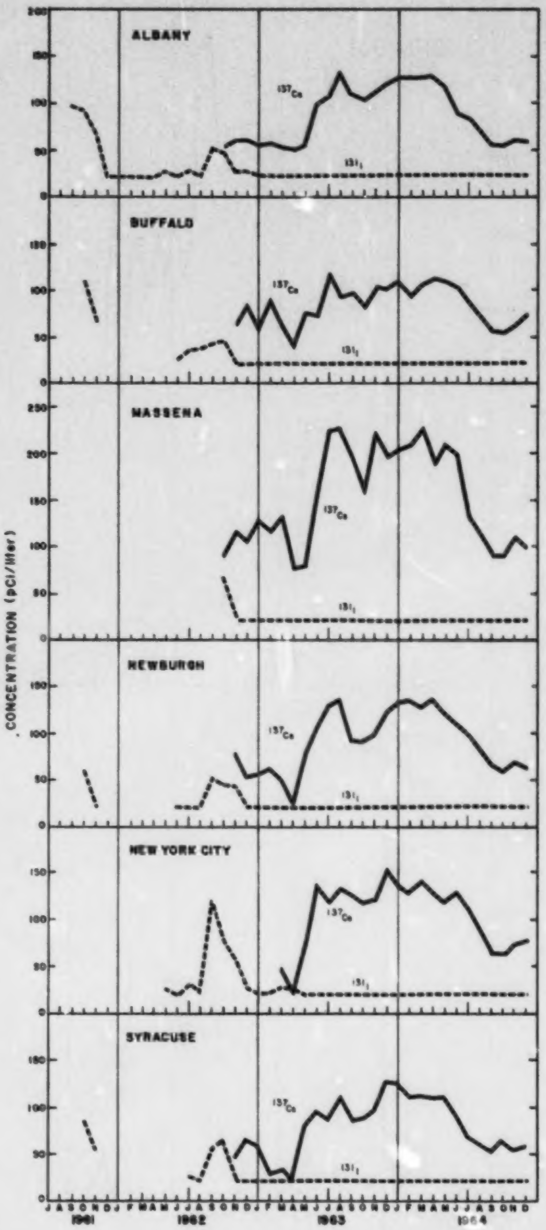

Figure 7. Cesium–137 and iodine–131 in New York milk, September 1961 to December 1964

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion exchange system. The collected cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution. The strontium isotopes are then gathered by means of sodium carbonate and isolated with ethylenediaminetetraacetic acid (EDTA). The radiostrontium is determined with a low-background beta counter having an 0.8 mg/cm^2 window. The strontium-90 is determined differentially from the 40-hour ingrowth of its daughter product, yttrium-90.

Results and discussion

The monthly average radionuclide concentrations of strontium-89, strontium-90, and cesium-137 are shown in table 7 for October to December 1964. During this period, the iodine-131 and barium-lanthanum-140 concentrations remained below the minimum detectable level of 20 pCi/liter.

The cesium-137 and iodine-131 concentrations since September 1961 are presented in figure 7. These results reflect a general decrease in cesium-137 since the atmospheric nuclear test ban treaty, despite the slight increase in October 1964.

Table 7. Average radionuclide concentrations (pCi/liter) in New York milk, October–December 1964

Sampling location	Strontium-89			Strontium-90			Cesium-137		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Albany	<3	<3	<3	14	14	14	57	61	60
Buffalo	3	<3	<3	11	13	13	50	60	73
Massena	5	4	<3	17	19	9	88	111	100
Newburgh	<3	<3	4	11	18	15	58	63	59
New York City	<3	<3	<3	16	21	20	64	74	78
Syracuse	<3	<3	<3	14	14	14	65	55	60
Average	<3	<3	<3	14	17	14	64	71	57

4. Canadian Milk Network[3]
March 1965

Radiation Protection Division,
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (figure 8) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

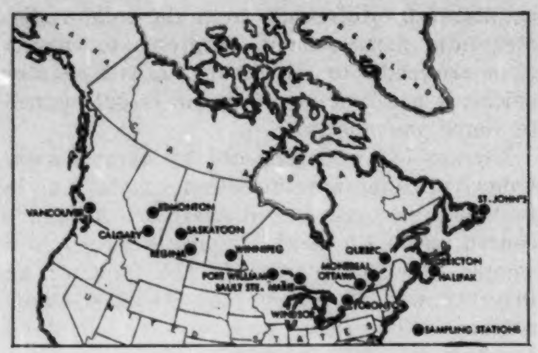

Figure 8. Canadian milk sampling stations

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine-131 (*6*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450° C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low-background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

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[3] Data from *Radiation Protection Programs*, Vol. 3, No. 4: 25-26. Radiation Protection Division, Canadian Department of National Health and Welfare (April 1965).

Cesium-137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accomodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radionuclide in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

Results

Table 9 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 8. Total error for various radionuclide concentrations in milk [a]

Radionuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Table 9. Radionuclides in Canadian whole milk, March 19[illegible] [a]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.5	24.8	108
Edmonton	1.14	1.5	22.3	116
Ft. William	1.11	1.7	43.0	193
Fredericton	1.13	1.7	33.3	196
Halifax	1.13	1.7	39.0	260
Montreal	1.04	1.7	26.4	164
Ottawa	1.16	1.7	21.6	126
Quebec	1.09	1.6	41.0	254
Regina	1.09	1.6	25.2	129
St. John's, Nfld	1.10	1.5	34.9	181
Saskatoon	1.13	1.7	26.4	112
Sault Ste. Marie	1.06	1.6	34.1	176
Toronto	1.02	1.7	13.3	88
Vancouver	1.16	1.6	36.3	251
Windsor	1.12	1.6	15.2	88
Winnipeg	1.11	1.7	27.2	151
Average	1.11	1.6	29.0	162

[a] Due to insignificant levels of strontiun-89 the reporting of this nuclide has been discontinued.

5. Pan American Milk Sampling Program March 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963 this was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine-131 and cesium-137 are determined by gamma scintillation spectrometry. Strontium-89, strontium-90, and barium-140 are determined radiochemically (*7*). Analytical errors are discussed in the 'Analytical Procedures' of article 1, "Pasteurized Milk Network," page 351.

Data presentation

Table 10 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations. The monthly average of iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

Table 10. Stable element and radionuclide concentrations in milk, March 1965

Sampling stations	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
	(g/liter)	(g/liter)	(pCi/liter)	(pCi/liter)	(pCi/liter)
Canal Zone:					
Cristobal	1.12	1.5	<5	4	35
Jamaica:					
Kingston	1.17	1.39	<5	18	275
Mandeville	ᵃ NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.12	1.6	<5	11	45
Venezuela:					
Caracas	1.19	1.47	<5	5	20

ᵃ NS indicates no sample collected during this period.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Rad Health Data 4:511–523 (October 1963).

(*2*) PUBLIC HEALTH SERVICE. Milk surveillance, pasteurized milk network, March 1964. Rad Health Data 5:309–317 (July 1964).

(*3*) PUBLIC HEALTH SERVICE. Milk surveillance, pasteurized milk network, December and annual summary 1964. Rad Health Data 6:193–202 (April 1965).

(*4*) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of Environmental Radioactivity, July 1964–December 1964. Coo–651–10 (February 1965).

(*5*) KAHN, B. et al. Rapid methods for estimating fission product concentrations in milk. Public Health Service Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

(*6*) DASGUPTA, A. K., and H. G. GREEN. A method for the radiochemical determination of iodine–131 in milk. RPD–23, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(*7*) PORTER, C. and B. KAHN. Improved determination of strontium–90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, APRIL 1964–MARCH 1965

Division of Radiological Health,
Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population intake. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3*, *4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution times permit this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter have been considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk for the twelve-month periods, March 1964–February 1965 and April 1964–March 1965 [a] (pCi/liter)

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Mar 1964–Feb 1965	Apr 1964–Mar 1965	Mar 1964–Feb 1965	Apr 1964–Mar 1965	Apr 1964–Feb 1965	Apr 1964–Mar 1965	Mar 1964–Feb 1965	Apr 1964–Mar 1965
Ala:	Montgomery	3	3	22	21	0	0	71	68
Alaska:	Palmer	4	4	20	20	0	0	105	99
Ariz:	Phoenix	3	2	5	5	0	0	29	28
Ark:	Little Rock	3	3	42	41	1	1	101	92
Calif:	Sacramento	3	3	7	7	0	0	38	35
	San Francisco	2	3	9	9	0	0	40	39
C. Z:	Cristobal	3	3	5	5	0	0	49	48
Colo:	Denver	3	3	19	19	0	0	88	82
Conn:	Hartford	3	3	19	18	0	0	120	112
Del:	Wilmington	3	3	22	22	1	1	101	96
D. C:	Washington	3	3	19	19	0	0	71	67
Fla:	Tampa	3	3	15	15	0	0	227	223
Ga:	Atlanta	3	3	29	29	0	0	119	112
Hawaii:	Honolulu	3	3	12	12	0	0	78	74
Idaho:	Idaho Falls	4	4	24	25	0	0	135	127
Ill:	Chicago	3	3	18	18	0	0	99	94
Ind:	Indianapolis	3	3	19	19	1	1	82	79
Iowa:	Des Moines	4	4	24	24	0	0	75	71
Kans:	Wichita	4	3	20	20	0	0	58	58
Ky:	Louisville	3	3	28	27	0	0	70	64
La:	New Orleans	3	4	49	47	0	0	120	113
Maine:	Portland	3	3	28	27	1	1	173	166
Md:	Baltimore	3	3	22	21	0	0	81	77
Mass:	Boston	3	4	29	28	0	0	182	172
Mich:	Detroit	3	3	17	17	2	2	98	95
	Grand Rapids	3	3	20	20	1	1	107	103
Minn:	Minneapolis	6	5	29	29	0	0	118	110
Miss:	Jackson	3	3	40	39	0	0	87	82
Mo:	Kansas City	4	4	25	25	0	0	68	63
	St. Louis	4	3	21	21	0	0	66	62
Mont:	Helena	4	3	22	21	1	1	133	123
Nebr:	Omaha	3	3	24	23	0	0	77	73
Nev:	Las Vegas	3	3	9	8	1	1	62	57
N. H:	Manchester	3	3	28	27	1	1	200	191
N. J:	Trenton	3	3	16	15	1	1	99	94
N. Mex:	Albuquerque	3	3	11	11	1	1	50	50
N. Y:	Buffalo	3	3	19	19	0	0	120	115
	New York	3	3	23	23	1	1	132	124
	Syracuse	3	3	18	17	0	0	115	108
N. C:	Charlotte	3	3	36	36	0	0	97	93
N. Dak:	Minot	10	8	52	53	0	0	140	137
Ohio:	Cincinnati	3	3	21	20	0	0	76	73
	Cleveland	3	3	20	20	0	0	100	97
Okla:	Oklahoma City	3	3	21	21	0	0	59	57
Ore:	Portland	5	5	28	28	0	0	139	135
Pa:	Philadelphia	3	3	19	19	0	0	98	93
	Pittsburgh	3	3	26	25	0	0	127	122
P. R:	San Juan	3	2	12	12	0	0	69	66
R. I:	Providence	3	3	22	22	0	0	136	129
S. C:	Charleston	3	3	31	31	0	0	113	110
S. Dak:	Rapid City	5	4	37	37	0	0	135	132
Tenn:	Chattanooga	3	3	29	28	0	0	98	92
	Memphis	3	3	31	30	0	0	61	57
Tex:	Austin	3	3	8	8	0	0	35	34
	Dallas	3	3	19	18	0	0	51	48
Utah:	Salt Lake City	5	5	24	24	0	0	152	143
Vt:	Burlington	3	3	24	24	2	2	147	140
Va:	Norfolk	3	3	18	18	0	0	81	77
Wash:	Seattle	6	5	27	27	0	0	139	137
	Spokane	5	5	25	26	0	0	124	121
W. Va:	Charleston	3	3	24	23	0	0	63	58
Wis:	Milwaukee	3	3	16	16	1	1	110	106
Wyo:	Laramie	6	5	19	18	0	0	95	89
Network average		3	3	22.7	22.4	0	0	100	95

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <10.
[b] Annual averages were computed on basis of 48 weekly averages.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides.

The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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RADIOSTRONTIUM IN CALIFORNIA MILK,[1] JANUARY 1960 THROUGH JUNE 1963

Arnold E. Greenberg,[2] Amasa C. Cornish,[3] George S. Uyesugi,[4] and John M. Heslep[5]

In 1960 the California State Department of Public Health, with the cooperation of a number of other State and local agencies, initiated a broad environmental radiological surveillance program. Samples of various environmental media are collected on a regular basis and analyzed for the biologically most important fission products. The purpose of this report is to describe portions of the program and to present information concerning radiostrontium in milk.

Sampling and analytical methods

Initially, eight milksheds were selected for study. This number was increased to ten in early 1962. The milksheds represent different climatic and geographic areas and include those which serve the State's major population centers. Seven of the milksheds range along the Pacific coast, while the others are located in the Central Valley (figure 1). The point of sampling within each milkshed is a processing plant, which handles milk from at least a thousand cows. Depending on the status of nuclear testing and general fallout levels, sampling frequency has varied from twice per week to once per month. Each sample consists of one gallon of milk taken from a bulk tank and is preserved with four milliliters of formalin in a polyethylene bottle.

In most areas, supplemental information on environmental radioactivity is collected. This includes data from radioanalyses of airborne particulates, precipitation, dry fallout, domestic water, and sewage.

Immediately upon receipt of a milk sample in the laboratory, it is transferred to a plastic Marinelli-type beaker and counted for 100 minutes, using a 4 x 4-inch NaI (Tl) crystal coupled to a 512-channel pulse height analyzer (*1*). The gamma spectral data (0–1.8 Mev) are analyzed for barium-lanthanum–140, potassium–40, cesium–137, and iodine–131. Subsequently, the strontium in a one liter sample is precipitated as carbonate and a beta count is made for total radiostrontium. Strontium–90 is inferred by chemically separating and counting its daughter, yttrium–90. Strontium–89 is determined by subtracting strontium–90 from total radiostrontium (*2*).

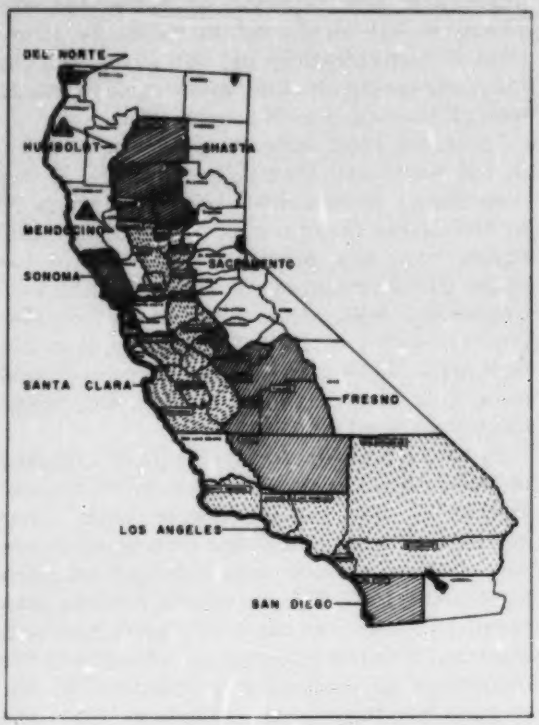

Figure 1. California milksheds

The strontium–90 content of milk samples collected during the period from January 1960 through June 1963 is shown graphically by month and milkshed in figure 2. From top to bottom the milksheds are arranged as they occur geographically from north to south. Until late 1961 strontium–90 concentrations were consistently very low. The effects of resumption of nuclear testing in September 1961 were first noted in a milk sample collected in mid-October from Humboldt County which had measurable concentrations of iodine–131 and strontium–90. Significant increases in strontium–90 concentrations did not occur until the following spring although measurable increases took place as early as November 1961.

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In March 1962, milk sampling was initiated in Del Norte and Mendocino Counties. It was immediately evident that levels of strontium–90 in Del Norte County milk were considerably higher than any previously observed in the State. The levels were not abnormally high in comparison with other parts of the country until the spring of 1963. The peak value of 270 picocuries of strontium–90 per liter was found in a milk sample collected from Del Norte County on April 23, 1963.

In 1962 a pronounced "spring peak" occurred in milk strontium–90 from Del Norte County and to a less marked degree from other northern California locations. This phenomenon was observed to some extent for all sampling locations in 1963. This, of course, has also been found by other investigators and it has been theorized that the principal causal factor is the occurrence of seasonal discontinuities in the stratosphere-troposphere interface (*3*). The effect is undoubtedly enhanced in areas such as northern California, where a large fraction of the annual rainfall occurs in late winter and spring.

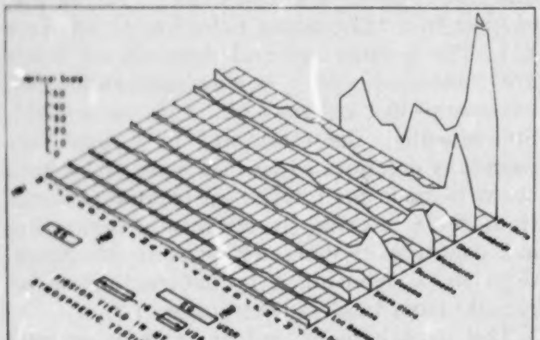

Figure 2. Strontium–90 in California milk, pCi/liter

Figure 3 shows the ratios of strontium–89 to strontium–90 by month for fallout and milk from Del Norte County. These data are useful in distinguishing fresh from old fission product debris and in estimating the "apparent" age of fallout material. They can also be used as an approximate internal check on the reliability of the analytical data. Since strontium–89 decays with a half-life of about 51 days, a semilogarithmic plot of the ratios with time should demonstrate this decay rate, as in figure 3.

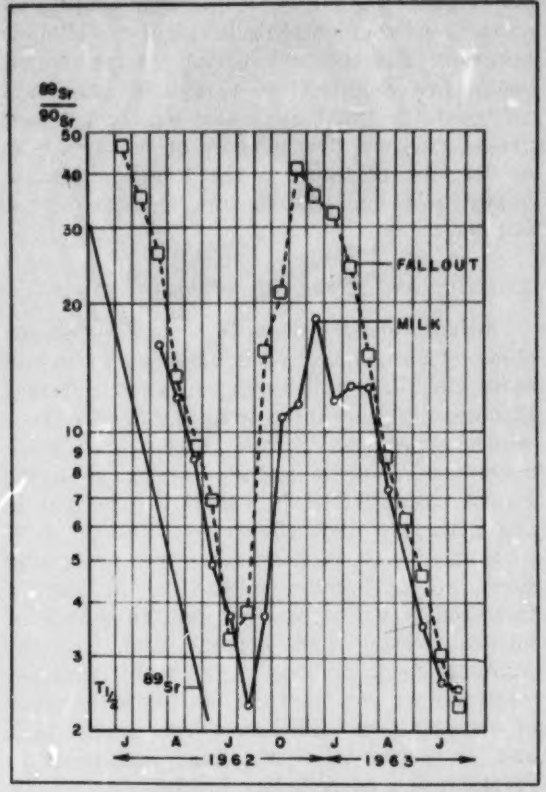

Figure 3. Strontium–89 to strontium–90 ratio in milk and fallout, Del Norte County, California

Table 1 gives ratios of cesium–137 to strontium–90 by month for milk from Del Norte and Humboldt Counties. The fact that over the interval of time involved these ratios remained relatively constant allowed the estimation of strontium–90 concentrations from cesium–137 measurements by gamma scan analysis. Figure 4 shows estimated strontium–90 values derived from cesium–137 values as well as the true values for strontium–90. There is no reason to believe that this empirical observation has any

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Table 1. Ratio of cesium-137 to strontium-90 in milk

Year	Month	Area	
		Del Norte	Humboldt
1961	October		4.3
	November		3.8
	December		3.7
1962	January		4.6
	February		6.5
	March	5.4	4.6
	April	2.8	7.7
	May	3.4	5.0
	June	3.3	3.1
	July	2.6	3.3
	August	3.6	5.2
	September	3.3	4.3
	October	3.2	4.7
	November	3.0	5.0
	December	3.1	3.4
1963	January	2.1	2.4
	February	3.3	4.3
	March	3.8	4.0
	April	2.9	2.8
	May	3.2	3.4
	June	3.8	3.9

universal validity but the same procedure might be useful over limited time periods for any given area.

It has been repeatedly shown that global distribution of fallout is non-uniform. Peak fallout has occurred in the north temperate zone, with a maximum at approximately 42–45° N latitude (*4*). There are also strong indications of a close relationship between precipitation and deposition of fission product debris. In California, which lies between the latitudes of approximately 32° and 42°N, rainfall and fallout vary considerably on a geographical basis, both generally decreasing from north to south, as shown in table 2. It can be seen, however, that neither rainfall nor latitude differences can satisfactorily account in full for variations in observed total fallout.

Discussion

In considering the strontium-90 content of milk, additional ecological and biological variables become important. Fallout components may enter the food chain either by direct foliar deposition or by plant root uptake from contaminated soil. Foliar deposition is related to the total amount and rate of fallout during the plant growing season. Root uptake is markedly influenced by soil chemistry and plant physiology, and is generally representative of longer term effects. Russell (*5*) found that foliar deposition accounted for 60–70 percent of milk strontium-90 in the first year after a test series, but only 30 percent in the second year. Other investigators have observed different percentages. A number of factors would be expected to cause such values to vary with time and location. The magnitude and relative constancy of the cesium-137/strontium-90 ratios which were observed would suggest that foliar deposition was the predominant consideration in California during 1962 and for at least the first half of 1963 (*6*).

The period covered by this study, together with the large variations found between different areas of a single State, affords an opportunity to evaluate several of the variables affecting strontium-90 in milk. During the first part of the period there was no atmospheric nuclear testing and low fallout. The latter part of the period permitted investigation of pertinent results of atmospheric testing involving some 100 megatons of fission energy.

Table 3 includes, for selected locations for 1962 and for the first six months of 1963: 1) the total picocuries of strontium-90 which

Table 2. Latitude, annual rainfall, and total beta deposition in milkshed areas

Location *	Latitude	Mean annual rainfall	1961		1962		Jan.–June, 1963	
			Rainfall	Total fallout	Rainfall	Total fallout	Rainfall	Total fallout
		inches	inches	nCi/m²	inches	nCi/m²	inches	nCi/m²
Del Norte, Crescent City	41°46′	70	76	1100	58	1490	39	1100
Humboldt, Eureka	40°48′	36	40	370	35	827	24	922
Shasta, Redding	40°34′	38	35	650	36	2050	25	1100
Sonoma, Santa Rosa	39°09′	29	21	336	28	785	18	724
Sacramento, Sacramento	38°31′	16	—	—	22	824	16	838
Fresno, Fresno	36°46′	9	7.2	193	10	448	11	575
Los Angeles, Los Angeles	33°56′	15	7.8	330	18	434	8.9	356
San Diego, San Diego	32°44′	11	5.3	278	8	462	2.6	202

* Data from cities listed under Location are presumed to be reasonably representative of the milksheds. This may be most in error for Del Norte where the mean annual rainfall in the milkshed area may be 15–30 percent higher than in Crescent City.

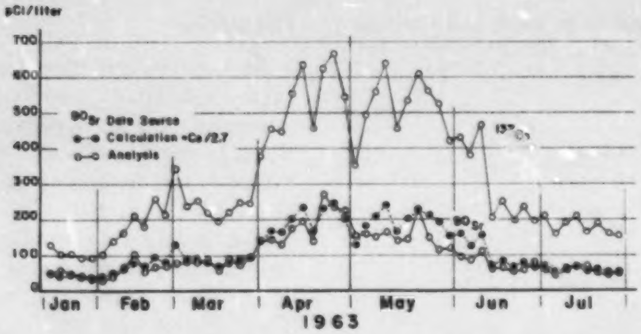

Figure 4. Cesium-137 and strontium-90 in Del Norte milk

would have been consumed as a consequence of drinking one liter of milk per day; 2) the total fallout strontium-90, during the same period, in picoucuries per square meter; and 3) the ratio of these two. It is readily apparent from the ratios, particularly for Del Norte County as compared with other areas of the State, that factors other than total strontium-90 fallout are of great importance in determining strontium-90 concentrations in milk. These factors must relate to the ecological and biological events between the occurrence of fallout and the appearance of strontium-90 in milk. One might expect to find an explanation on the basis of such agricultural practices as land management and cattle feeding patterns.

Table 3. Strontium-90 in total fallout and in milk

Milkshed	1962			January-June 1963		
	Total pCi ^{90}Sr from 1 liter/day (A)	Total fallout ^{90}Sr pCi/m^2 (B)	Ratio A/B	Total pCi ^{90}Sr from 1 liter/day (A)	Total fallout ^{90}Sr pCi/m^2 (B)	Ratio A/B
Del Norte	12,200	2,990	4.1	18,200	4,330	4.2
Sonoma	1,800	2,240	0.8	3,230	3,320	0.9
Sacramento	1,240	2,110	0.6	1,600	2,420	0.3
Fresno	960	2,110	0.5	1,060	6,320	0.2
Los Angeles	830	1,540	0.5	645	2,580	0.2
San Diego	865	2,890	0.3	620	2,420	0.3

A careful and detailed study in the St. Louis area (*7*) clearly demonstrated that wide variations in milk strontium-90 and iodine-131 from different farms in the same area could be accounted for solely by differences in land management and fertilization practices. It is suggested that milk strontium-90 concentration is inversely proportional to the weight of plant material produced per unit area of land.

The data presented in this paper cannot be used as a direct test of this statement. On the other hand, it appears reasonably logical on intuitive grounds. Field observations in northern California substantiate it qualitatively. A special study now under way in Del Norte, Humboldt, and Shasta counties has as its objectives a more detailed elucidation of factors influencing strontium-90 levels in milk and means by which such levels might be reduced by changes in agricultural practices.

Summary and conclusions

Data on strontium-90 in California milk from January 1960 through June 1963 have been presented and analyzed. Within the State, levels of milk strontium-90 have varied from among the lowest to the highest values reported in the United States. These differences are due in part to geographical and climatic conditions in which rainfall with its attendant burden of fission products is the single most important factor. Climate alone does not account for all the differences; agricultural practices must also play a significant role. These factors are currently under investigation.

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RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, OCTOBER–DECEMBER AND ANNUAL AVERAGES, 1964

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Total Diet Sampling Network in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially the program was conducted at eight institutions; as of December 1964 its scope had increased to 46 boarding schools or institutions, distributed as shown in figure 1. These institutions range from financially well-to-do boarding schools to orphanages with severe economic limitations. All but five of the stations are located in a community where the PHS Pasteurized Milk Network collects samples; special or State milk samples are obtained from Los Angeles, California; Columbia, Mississippi; Carson City, Nevada; Sioux Falls, South Dakota; and Fargo, North Dakota.

Sampling procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a randomly selected individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each daily sample is kept frozen until the end of the collection period. The total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

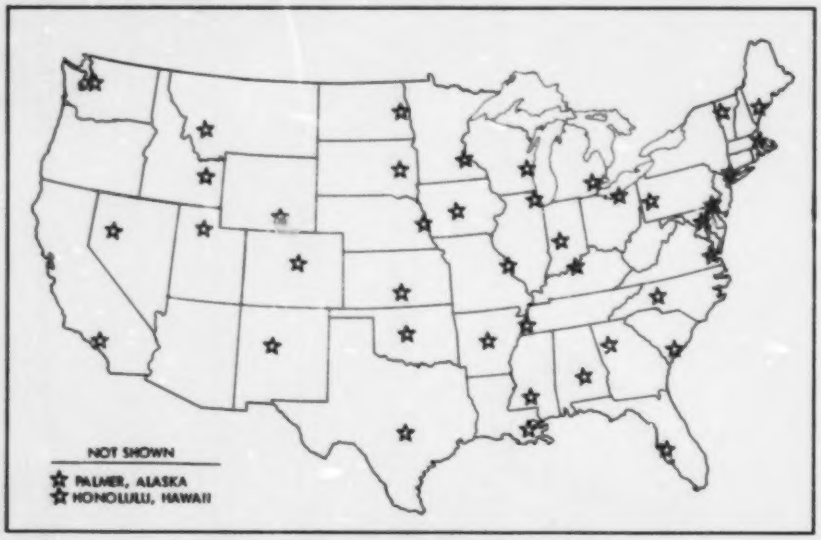

Figure 1. Institutional diet sampling locations

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Table 1. Institutional diet analytical results (based on a 7-day composite sample each month), fourth quarter 1964

Location of institution	Age (years)	Month (1964)	Dietary consumption (kg/day)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg [a]			
				Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Ala., Montgomery	15-17	Oct	2.43	0.5	1.0	<5	13	45	[b] NA
	15-17	Nov	2.17	0.4	1.2	10	15	45	NA
	15-17	Dec	2.34	0.5	1.2	<5	17	50	NA
Alaska, Palmer	11	Oct	1.57	0.4	1.6	<5	20	80	0.6
	10-12	Nov	1.62	0.5	1.1	<5	14	75	0.5
	10-12	Dec	1.45	0.4	1.6	<5	14	100	0.9
Ark., Little Rock	10-12	Oct	1.72	0.8	1.1	<5	28	50	NA
	11-12	Nov	1.82	0.7	1.2	<5	19	50	NA
	11-12	Dec	1.92	0.7	1.1	<5	27	35	NA
Calif., Los Angeles	12-13	Oct	2.21	0.6	1.3	<5	8	55	0.7
	12-14	Nov	2.03	0.8	1.7	<5	8	20	0.2
	11-15	Dec	1.35	0.5	1.3	<5	18	35	0.9
Colo., Denver	10-12	Oct	2.50	0.7	1.5	<5	16	50	1.1
	10-12	Nov	2.28	0.8	1.7	<5	8	30	0.6
	10-12	Dec	1.94	0.5	1.4	<5	10	55	0.8
Conn., Hartford	15-18	Oct	1.82	0.6	1.3	<5	8	70	0.4
	12-18	Nov	1.78	0.6	1.6	<5	9	70	0.3
	13-18	Dec	1.87	0.7	1.7	<5	13	90	0.8
Del., Wilmington	11-12	Oct	1.87	0.8	1.7	<5	13	85	0.7
	11 12	Nov	1.94	0.8	1.6	<5	13	65	0.6
	11-12	Dec	1.86	0.7	1.7	<5	11	65	0.7
Fla., Tampa	9-12	Oct	2.20	0.7	1.2	<5	17	125	NA
	10-13	Nov	1.90	0.7	1.4	5	16	140	NA
	10-12	Dec	2.39	0.8	1.2	<5	16	165	NA
Ga., Atlanta	5-14	Oct	1.47	0.6	1.2	10	26	70	NA
	8-17	Nov	1.93	0.7	1.6	<5	27	60	NA
	14-17	Dec	1.84	0.8	1.5	<5	28	60	NA
Hawaii, Honolulu	15-17	Oct	1.69	0.6	1.3	<5	22	75	0.6
	14-17	Nov	1.73	0.6	1.1	<5	6	50	0.9
	15-17	Dec	1.49	0.4	1.4	<5	12	105	0.4
Idaho, Idaho Falls	16-17	Oct	2.23	0.7	1.1	<5	13	50	[b] NA
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	17	Dec	1.65	0.7	1.5	<5	16	100	1.3
Ill., Chicago	12	Oct	1.57	0.6	1.6	<5	9	65	0.6
	11-12	Nov	1.40	0.8	1.4	<5	12	70	0.5
	9-12	Dec	1.48	0.7	1.6	<5	12	70	0.8
Ind., Indianapolis	10-12	Oct	1.56	0.8	1.5	<5	11	55	0.6
	11-12	Nov	1.76	0.8	1.6	<5	11	60	0.7
	10-12	Dec	1.61	0.7	1.5	<5	9	75	0.6
Iowa, Des Moines	15-16	Oct	2.84	0.8	1.2	5	22	60	NA
	15-17	Nov	3.15	0.6	1.6	<5	15	45	NA
	15-17	Dec	3.04	0.7	1.5	<5	14	55	NA
Kans., Wichita	10	Oct	2.26	0.6	1.2	<5	9	35	NA
	12	Nov	2.63	0.4	1.3	<5	10	40	NA
	10	Dec	1.95	0.7	1.5	<5	14	35	NA
Ky., Louisville	15-17	Oct	2.11	0.9	1.0	5	25	30	NA
	15-16	Nov	1.64	0.5	1.3	<5	14	40	NA
	15-17	Dec	2.12	0.8	1.2	<5	21	45	NA
La., New Orleans	15-17	Oct	2.48	0.7	1.2	<5	22	50	NA
	15-17	Nov	2.69	0.6	1.4	<5	21	60	NA
	15-16	Dec	2.60	0.5	1.3	<5	25	45	NA
Maine, Portland	15-16	Oct	2.44	0.7	1.6	<5	18	90	0.7
	14-15	Nov	2.30	0.8	1.4	<5	17	105	0.8
	14	Dec	2.37	0.8	1.5	<5	19	100	0.7
Md., Baltimore	11-12	Oct	1.83	0.6	1.2	5	15	50	NA
	11-12	Nov	1.93	0.8	1.6	<5	15	50	NA
	10-12	Dec	1.93	0.7	1.2	10	15	60	NA
Mass., Boston	10-12	Oct	1.55	0.8	1.6	<5	15	105	0.4
	10-12	Nov	1.55	0.7	1.3	5	16	90	0.4
	10-12	Dec	1.55	0.7	1.6	<5	15	115	0.4
Mich., Detroit	10-12	Oct	1.93	0.8	1.5	<5	10	75	1.1
	10-12	Nov	2.13	0.6	1.2	<5	10	65	0.7
	11-12	Dec	2.04	0.6	1.4	<5	12	70	0.7
Miss., Columbia	15-18	Oct	2.32	1.4	1.0	<5	41	75	NA
	13-18	Nov	1.71	0.8	1.3	<5	33	90	NA
	15-17	Dec	2.06	0.9	1.4	10	23	70	NA
Mo., St. Louis	15-18	Oct	2.34	0.7	1.6	<5	22	55	1.2
	15-17	Nov	2.06	0.6	1.1	<5	20	45	1.4
	15-17	Dec	1.63	0.5	1.5	<5	15	80	0.5
Mont., Helena	16	Oct	1.52	0.7	2.0	<5	14	65	0.8
	15	Nov	1.81	0.5	1.2	<5	10	80	0.9
	15-16	Dec	1.60	0.5	1.2	<5	12	80	0.7
Nebr., Omaha	15	Oct	2.28	0.7	1.5	<5	16	40	0.7
	15-16	Nov	1.98	0.8	1.4	<5	23	55	1.7
	15-18	Dec	1.63	0.5	1.3	<5	13	55	0.4
Nev., Carson City	15-17	Oct	1.90	0.7	1.6	<5	10	45	0.9
	15-17	Nov	1.72	0.7	1.4	<5	10	55	0.7
	14-15	Dec	1.26	0.7	1.3	<5	17	50	1.4
N. J., Trenton	15-17	Oct	2.46	0.6	1.3	<5	10	85	1.2
	14-16	Nov	2.34	0.5	1.3	<5	11	70	1.1
	15-17	Dec	2.32	0.4	1.6	<5	10	10	1.4
N. Mex., Albuquerque	10-12	Oct	1.73	0.8	1.5	<5	14	50	0.4
	10-12	Nov	1.85	1.7	1.6	<5	12	70	0.6
	10-12	Dec	1.63	0.8	1.7	<5	13	45	1.3
N. Y., New York	(c)	Oct	NS	NS	NS	NS	NS	NS	NS
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	6-17	Dec	2.08	0.6	1.6	<5	11	75	0.6
N. C., Charlotte	15-18	Oct	1.64	0.7	1.0	10	25	55	NA
	13-17	Nov	1.77	0.9	1.0	<5	32	55	NA
	13-18	Dec	1.43	0.7	1.1	<5	21	55	NA
N. D., Fargo	10-12	Oct	1.48	0.8	1.6	<5	18	75	1.5
	10-12	Nov	1.46	0.9	1.3	<5	14	70	0.4
	7-12	Dec	1.12	0.6	1.5	<5	16	70	0.4
Ohio, Cleveland	10-12	Oct	2.03	0.6	1.5	<5	12	65	0.5
	10	Nov	1.65	0.7	1.7	<5	12	70	0.5
	10-12	Dec	1.56	0.7	1.4	<5	12	60	0.5

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Table 1. Institutional diet analytical results (based on a 7-day composite sample each month), fourth quarter 1964—Continued

Location of institution	Age (years)	Month (1964)	Dietary consumption (kg/day)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg [a]			
				Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Okla., Oklahoma City	11–14	Oct	1.90	0.8	1.2	<5	14	40	NA
	11–12	Nov	1.73	0.7	1.5	<5	16	45	NA
	11–12	Dec	1.76	0.8	1.5	<5	16	40	NA
Oreg., Portland	13–17	Oct	2.41	0.5	1.5	<5	11	55	0.5
	13–17	Nov	2.31	0.6	1.9	<5	10	55	0.9
	13–17	Dec	1.46	0.4	2.0	<5	11	80	0.7
Pa., Pittsburgh	15–16	Oct	1.90	0.7	1.4	<5	17	75	0.8
	14–16	Nov	1.93	0.7	1.5	<5	18	80	0.8
	14–16	Dec	2.10	0.6	1.5	<5	14	70	0.7
S. C., Charleston	7–12	Oct	1.69	0.5	0.9	<5	17	50	NA
	7–15	Nov	1.87	0.4	1.2	<5	19	80	NA
	(c)	Dec	NS	NS	NS	NS	NS	NS	NS
S. D., Sioux Falls	(c)	Oct	NS	NS	NS	NS	NS	NS	NS
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	10–12	Dec	1.62	0.7	1.8	<5	19	90	0.5
Tenn., Memphis	15–16	Oct	1.83	0.6	1.1	10	13	40	NA
	15–16	Nov	1.34	0.4	1.0	<5	16	25	NA
	14–17	Dec	1.56	0.6	1.5	<5	14	45	NA
Tex., Austin	14–16	Oct	1.98	0.5	1.0	5	8	30	NA
	14–15	Nov	2.02	0.5	1.1	<5	15	30	NA
	13–17	Dec	2.27	0.5	1.0	<5	10	25	NA
Utah, Salt Lake City	12–18	Oct	1.05	0.7	1.5	<5	15	75	1.0
	15–17	Nov	1.21	0.6	1.5	<5	6	50	0.3
	12–18	Dec	1.41	0.5	1.6	<5	14	85	0.6
Vt., Burlington	11–12	Oct	1.77	0.5	1.4	<5	10	70	0.6
	11–12	Nov	1.60	0.7	1.7	<5	13	75	1.0
	10–12	Dec	1.42	0.7	1.8	<5	13	90	0.8
Va., Norfolk	15–16	Oct	2.20	0.5	1.0	5	17	55	NA
	14–17	Nov	2.20	0.5	1.0	<5	20	60	NA
	15–17	Dec	2.22	0.5	1.0	5	14	45	NA
Wash., Seattle	15–17	Oct	1.69	0.7	1.7	<5	15	85	0.7
	15–17	Nov	1.83	0.8	1.7	<5	32	95	0.4
	16–17	Dec	1.12	0.5	1.5	<5	21	100	0.4
W. Va., Charleston	10–12	Oct	1.92	0.7	1.3	<5	20	65	NA
	10–12	Nov	1.80	0.7	1.8	<5	25	70	NA
	10–12	Dec	1.76	0.8	1.2	<5	27	70	NA
Wisc., Milwaukee	15–17	Oct	2.63	0.6	1.6	<5	8	70	0.6
	15–17	Nov	2.46	0.7	1.4	<5	9	60	0.6
	13–17	Dec	2.22	0.7	1.5	<5	8	65	0.5
Wyo., Laramie	11	Oct	1.61	0.7	1.6	<5	12	55	0.9
	11	Nov	1.52	0.7	1.7	<5	13	65	1.1
	11	Dec	1.41	0.7	1.7	<5	15	80	NA
Institution average		Oct	1.97	0.7	1.4	<5	16	60	0.8
		Nov	1.92	0.7	1.4	<5	15	60	0.7
		Dec	1.81	0.6	1.4	<5	15	70	0.7

[a] All barium-140 and iodine-131 levels were below the minimum detectable concentration (10 pCi/kg).
[b] NA indicates no analysis.
[c] NS indicates no sample received.

The sample for each day is packaged in three parts: (1) solid food and semi-solid food minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking water is not included in these samples; however, a water sample is collected from each institution at least once a year for analysis. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample. Sample volumes usually range from 6 to 16 liters; sample weights range from 8 to 20 kilograms.

Analytical procedures

Because calcium compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Stable calcium and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods.

The radioanalysis program is designed around three basic procedures: (1) gamma spectrometry; (2) chemical separation of strontium with subsequent counting for strontium–89 and strontium–90; and (3) radium–226 analysis. In the absence of interferences other than that from naturally occurring radioactive potassium (^{40}K), minimum detectable concentrations for iodine–131, cesium–137, and barium–140 by gamma spectrometry are 10 pCi/kg. Approximate minimum detectable concentrations for strontium–89, strontium–90, and radium-226 are: 5, 1, and 1 pCi/kg, respectively.

Data

Table 1 gives the results of the laboratory

Table 2. Institutional diet daily intakes (based on a 7-day composite sample each month), fourth quarter 1964

Location of institution	Age (years)	Month (1964)	Dietary consumption (kg/day)	Stable elements, g/day		Radionuclide concentrations, pCi/day [a]			
				Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Ala., Montgomery	15–17	Oct	2.43	1.2	2.4	5	32	110	[b] NA
	15–17	Nov	2.17	0.9	2.6	20	33	100	NA
	15–17	Dec	2.34	1.2	2.8	5	40	115	NA
Alaska, Palmer	11	Oct	1.57	0.6	2.5	5	31	125	1
	10–12	Nov	1.62	0.8	1.6	5	23	120	1
	10–12	Dec	1.45	0.6	2.3	5	20	145	1
Ark., Little Rock	10–12	Oct	1.72	1.4	1.9	5	48	85	NA
	11–12	Nov	1.82	1.3	2.2	5	35	90	NA
	11–12	Dec	1.92	1.3	2.1	5	52	65	NA
Calif., Los Angeles	12–13	Oct	2.21	1.3	2.9	5	18	120	2
	12–14	Nov	2.03	1.6	3.5	5	16	40	0
	11–15	Dec	1.35	0.7	1.6	5	24	45	1
Colo., Denver	10–12	Oct	2.50	1.8	3.8	5	40	125	3
	10–12	Nov	2.28	1.8	3.9	5	18	70	1
	10–12	Dec	1.94	1.0	2.7	5	19	105	2
Conn., Hartford	15–18	Oct	1.82	1.1	2.4	5	15	125	1
	12–18	Nov	1.78	1.1	2.8	5	16	125	1
	13–18	Dec	1.87	1.3	3.2	5	24	170	1
Del., Wilmington	11–12	Oct	1.87	1.5	3.2	5	24	160	1
	11–12	Nov	1.94	1.6	3.1	5	25	125	1
	11–12	Dec	1.86	1.3	3.2	5	20	120	1
Fla., Tampa	9–12	Oct	2.20	1.5	2.6	5	37	275	NA
	10–13	Nov	1.90	1.3	2.7	10	30	265	NA
	10–12	Dec	2.39	1.9	2.9	5	38	395	NA
Ga., Atlanta	5–14	Oct	1.47	0.9	1.8	15	38	105	NA
	8–17	Nov	1.93	1.4	3.1	5	52	115	NA
	14–17	Dec	1.84	1.5	2.8	5	52	110	NA
Hawaii, Honolulu	15–17	Oct	1.69	1.0	2.2	5	37	125	1
	14–17	Nov	1.73	1.0	1.9	5	10	85	2
	15–17	Dec	1.49	0.6	2.1	5	18	155	1
Idaho, Idaho Falls	16–17	Oct	2.23	1.6	2.5	5	29	110	NA
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	17	Dec	1.65	1.2	2.5	5	26	165	2
Ill., Chicago	12	Oct	1.57	0.9	2.5	5	14	100	1
	11–12	Nov	1.40	1.1	2.0	5	17	100	1
	9–12	Dec	1.48	1.0	2.4	5	18	105	1
Ind., Indianapolis	10–12	Oct	1.56	1.2	2.3	5	17	85	1
	11–12	Nov	1.76	1.4	2.8	5	19	105	1
	10–12	Dec	1.61	1.1	2.4	5	14	120	1
Iowa, Des Moines	15–16	Oct	2.84	2.3	3.4	15	62	170	NA
	15–17	Nov	3.15	1.9	5.0	10	47	140	NA
	15–17	Dec	3.04	2.1	4.6	10	43	165	NA
Kans., Wichita	10	Oct	2.26	1.4	2.7	5	20	80	NA
	12	Nov	2.63	1.1	3.4	5	26	105	NA
	10	Dec	1.95	1.4	2.9	5	27	70	NA
Ky., Louisville	15–17	Oct	2.11	1.9	2.1	10	53	65	NA
	15–16	Nov	1.64	0.8	2.1	5	23	65	NA
	15–17	Dec	2.12	1.7	2.5	5	45	95	NA
La., New Orleans	15–17	Oct	2.48	1.7	3.0	5	55	125	NA
	15–17	Nov	2.69	1.6	3.8	5	56	160	NA
	15–16	Dec	2.60	1.3	3.4	5	65	115	NA
Maine, Portland	15–16	Oct	2.44	1.7	3.9	5	44	220	2
	14–15	Nov	2.30	1.8	3.2	5	39	240	2
	14	Dec	2.37	1.9	3.6	5	45	235	2
Md., Baltimore	11–12	Oct	1.83	1.1	2.2	10	27	90	NA
	11–12	Nov	1.93	1.5	3.1	5	29	95	NA
	11–12	Dec	1.93	1.4	2.3	20	29	115	NA
Mass., Boston	10–12	Oct	1.55	1.2	2.5	5	23	165	1
	10–12	Nov	1.55	1.1	2.0	10	25	140	1
	10–12	Dec	1.55	1.1	2.5	5	23	180	1
Mich., Detroit	10–12	Oct	1.93	1.5	2.9	5	19	145	2
	10–12	Nov	2.13	1.3	2.6	5	21	140	1
	11–12	Dec	2.04	1.2	2.9	5	24	145	1
Miss., Columbia	15–18	Oct	2.32	3.2	2.3	5	95	175	NA
	13–18	Nov	1.71	1.4	2.2	5	56	155	NA
	15–17	Dec	2.06	1.9	2.9	20	47	145	NA
Mo., St. Louis	15–18	Oct	2.34	1.6	3.7	5	51	130	3
	15–17	Nov	2.06	1.2	2.3	5	41	95	3
	15–17	Dec	1.63	0.8	2.4	5	24	130	1
Mont., Helena	16	Oct	1.52	1.1	3.0	5	21	100	1
	15	Nov	1.81	0.9	2.2	5	18	145	2
	15–16	Dec	1.60	0.8	1.9	5	19	130	1
Nebr., Omaha	15	Oct	2.28	1.6	3.4	5	36	90	2
	15–16	Nov	1.98	1.6	3.0	5	46	110	3
	15–18	Dec	1.63	0.8	2.1	5	21	90	1
Nev., Carson City	15–17	Oct	1.90	1.3	3.0	5	19	85	2
	15–17	Nov	1.72	1.2	2.4	5	17	95	1
	14–15	Dec	1.26	0.9	1.6	5	21	65	2
N. J., Trenton	15–17	Oct	2.46	1.5	3.2	5	25	210	3
	14–16	Nov	2.34	1.2	3.0	5	26	165	3
	15–17	Dec	2.32	0.9	3.7	5	23	140	3
N. Mex., Albuquerque	10–12	Oct	1.73	1.4	2.6	5	24	85	1
	10–12	Nov	1.85	3.1	3.0	5	22	130	1
	10–12	Dec	1.63	1.3	2.8	5	21	75	2
N. Y., New York	(c)	Oct	NS	NS	NS	NS	NS	NS	NS
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	6–17	Dec	2.08	1.2	3.3	5	23	155	1
N. C., Charlotte	15–18	Oct	1.64	1.1	1.6	15	41	90	NA
	13–17	Nov	1.77	1.6	1.8	5	57	95	NA
	13–18	Dec	1.43	1.0	1.6	5	30	80	NA
N. Dak., Fargo	10–12	Oct	1.48	1.2	2.4	5	27	110	2
	10–12	Nov	1.46	1.3	1.9	5	20	100	1
	7–12	Dec	1.12	0.7	1.7	5	18	80	0

Table 2. Institutional diet daily intakes (based on a 7-day composite sample each month), fourth quarter 1964—Continued

Location of institution	Age (years)	Month (1964)	Dietary consumption (kg/day)	Stable elements, g/day		Radionuclide concentrations, pCi/day [a]			
				Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Ohio, Cleveland	10-12	Oct	2.03	1.2	3.0	5	24	130	1
	10	Nov	1.65	1.2	2.8	5	20	115	1
	10-12	Dec	1.56	1.1	2.2	5	19	95	1
Okla., Oklahoma City	11-14	Oct	1.90	1.5	2.3	5	27	75	NA
	11-12	Nov	1.73	1.2	2.6	5	28	80	NA
	11-12	Dec	1.76	1.4	2.6	5	28	70	NA
Oreg., Portland	13-17	Oct	2.41	1.2	3.6	5	27	135	1
	13-17	Nov	2.31	1.4	4.4	5	23	125	2
	13-17	Dec	1.46	0.6	2.9	5	16	115	1
Pa., Pittsburgh	15-16	Oct	1.90	1.3	2.7	5	32	140	2
	14-16	Nov	1.93	1.4	2.9	5	35	155	2
	14-16	Dec	2.10	1.3	3.2	5	29	145	1
S. C., Charleston	7-12	Oct	1.69	0.8	1.5	5	29	85	NA
	7-15	Nov	1.87	0.7	2.2	5	36	150	NA
	(c)	Dec	NS	NS	NS	NS	NS	NS	NS
S. Dak., Sioux Falls	(c)	Oct	NS	NS	NS	NS	NS	NS	NS
	(c)	Nov	NS	NS	NS	NS	NS	NS	NS
	10-12	Dec	1.62	1.1	2.9	5	31	145	1
Tenn., Memphis	15-16	Oct	1.83	1.1	2.0	20	24	75	NA
	15-16	Nov	1.34	0.5	1.3	5	21	35	NA
	14-17	Dec	1.56	0.9	2.3	5	22	70	NA
Tex., Austin	14-16	Oct	1.98	1.0	2.0	10	16	60	NA
	14-15	Nov	2.02	1.0	2.2	5	30	60	NA
	13-17	Dec	2.27	1.1	2.3	5	23	55	NA
Utah, Salt Lake City	12-18	Oct	1.05	0.7	1.6	5	16	80	1
	15-17	Nov	1.21	0.7	1.8	5	7	60	0
	12-18	Dec	1.41	0.7	2.3	5	20	120	1
Vt., Burlington	11-12	Oct	1.77	0.9	2.5	5	18	125	1
	11-12	Nov	1.60	1.1	2.7	5	21	120	2
	10-12	Dec	1.42	1.0	2.6	5	18	130	1
Va., Norfolk	15-16	Oct	2.20	1.1	2.2	10	37	120	NA
	14-17	Nov	2.20	1.1	2.2	5	44	130	NA
	15-17	Dec	2.22	1.1	2.2	10	31	100	NA
Wash., Seattle	15-17	Oct	1.69	1.2	2.9	5	25	145	1
	15-17	Nov	1.83	1.5	3.1	5	50	175	1
	16-17	Dec	1.12	0.6	1.7	5	24	110	0
W. Va., Charleston	10-12	Oct	1.92	1.3	2.5	5	38	125	NA
	10-12	Nov	1.80	1.3	3.2	5	45	125	NA
	10-12	Dec	1.76	1.4	2.1	5	48	125	NA
Wisc., Milwaukee	15-17	Oct	2.63	1.6	4.2	5	21	185	2
	15-17	Nov	2.46	1.7	3.4	5	22	150	1
	13-17	Dec	2.22	1.6	3.3	5	18	145	1
Wyo., Laramie	11	Oct	1.61	1.1	2.6	5	19	90	1
	11	Nov	1.52	1.1	2.6	5	20	100	2
	11	Dec	1.41	1.0	2.4	5	21	115	NA
Institution Average		Oct	1.97	1.3	2.6	5	31	120	2
		Nov	1.92	1.3	2.7	5	30	120	1
		Dec	1.81	1.2	2.6	5	28	125	1

[a] All barium-140 and iodine-131 analyses indicate levels below detection limits.
[b] NA indicates no analysis.
[c] NS indicated no sample received.

analyses of the food samples collected during October through December 1964. Stable elements are reported in grams per kilogram of diet, and radionuclide concentrations are expressed as picocuries per kilogram of diet.

Table 2 presents the dietary intake data expressed on a per-day basis from October through December 1964 for the 46 institutions from which samples were received. The intake values in this table were obtained by multiplying the food consumption rate in kg/day times the concentration values in grams or picocuries per kilogram of diet (given in table 1). Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radiochemical results are reported by the laboratories as being "less-than" (<) a specified value. For data computations "less-than" values were interpreted as zero for <10 pCi/kg values for iodine-131 and barium-140 and 2.5 pCi/kg for strontium-90, and <5 pCi/kg of strontium-89.

From table 1 it is seen that for the last quarter of 1964 the average food intake ranged from 1.05 to 3.15 kg/day with an average of 1.90 kg/day.

From table 2 it is seen that the calcium intake ranged from 0.5 to 3.2 g/day with the network average being 1.3 g/day. Potassium intake ranged from 1.3 to 5.0 g/day around an average of 2.6 g/day.

Strontium-89 intakes ranged from 5 to 20 pCi/day with an average of 5 pCi/day. The strontium-90 intakes during this quarter

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averaged 30 pCi/day and ranged from 7 to 95 pCi/day. The daily intake was greater than 62 pCi/day at only one station. Applicable guidance given by the Federal Radiation Council (FRC) Range II for strontium–89 is 200 to 2000 pCi/day. The FRC Range II for strontium–90 is 20 to 200 pCi/day (*3*).

Although the intake of cesium–137 ranged from 35 to 395 pCi/day, the network average for October to December 1964 remained around 120 pCi/day. The high value was observed in Tampa, Florida, reflecting continuing higher cesium–137 levels in Florida milk relative to the national average.

During this quarter, both barium–140 and iodine–131 concentrations were below detectable levels.

Annual averages

Annual average radionuclide concentrations in 1964 institutional total diet samples are given in table 3. Table 4 presents the annual average radionuclide intakes as determined for 1964 by the Institutional Total Diet Sampling Network. The annual average daily intake varied from 1.39 to 2.58 kg/day, with a mean of 1.93 kg/day. Annual average calcium intakes ranged from 0.8 to 1.9 grams per day, with a mean of 1.2 grams/day. Potassium annual average daily intakes ranged from 1.9 to 3.7 grams per day with a mean of 2.6 grams per day.

Annual average daily intakes of strontium–89 in 1964 ranged from 0 to 15 pCi/day with an overall average of 5 pCi/day. These values

Table 3. Annual average calcium, potassium, and radionuclide concentrations in institutional dietary analysis program, 1964

Location of institution	Total wgt. (kg./day)	(grams per kg)		Radionuclide concentrations, pCi/kg [a]			
		Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Ala., Montgomery [c]	2.23	0.5	1.1	<5	13	45	NA
Alaska, Palmer	1.50	0.6	1.4	<5	20	105	0.7
Ark., Little Rock	1.79	0.6	1.2	<5	26	65	[b] 1.9
Calif., Los Angeles	1.79	0.6	1.6	<5	19	50	0.6
Colo., Denver	2.42	0.6	1.5	<5	13	60	0.7
Conn., Hartford [c]	1.86	0.6	1.5	<5	11	80	0.5
Del., Wilmington	1.88	0.8	1.6	<5	16	90	0.6
Fla., Tampa	2.16	0.7	1.2	<5	14	135	[b] 1.9
Ga., Atlanta	2.01	0.5	1.2	<5	20	60	[b] 1.1
Hawaii, Honolulu	1.71	0.5	1.3	5	11	70	0.9
Idaho, Idaho Falls	1.94	0.6	1.5	<5	24	125	0.6
Ill., Chicago [c]	1.57	0.7	1.5	<5	14	90	0.5
Ind., Indianapolis [c]	1.69	0.8	1.6	<5	13	65	0.7
Iowa, Des Moines [c]	2.56	0.7	1.2	<5	19	55	NA
Kans., Wichita [c]	2.12	0.6	1.3	<5	13	50	NA
Ky., Louisville [c]	1.95	0.7	1.1	<5	20	40	NA
La., New Orleans	2.58	0.6	1.4	<5	26	90	[b] 2.4
Maine, Portland	2.29	0.7	1.5	<5	20	120	0.6
Md., Baltimore [c]	1.96	0.7	1.3	<5	18	60	NA
Mass., Boston	1.69	0.7	1.6	<5	20	150	0.4
Mich., Detroit [c]	2.01	0.7	1.4	<5	12	75	0.8
Minn., Minneapolis	1.74	0.5	1.4	5	18	90	0.7
Miss., Columbia	1.97	0.9	1.3	5	31	125	[b] 3.0
Mo., St. Louis	2.43	0.6	1.4	5	19	60	0.9
Mont., Helena	2.02	0.5	1.2	<5	15	90	0.6
Nebr., Omaha	2.03	0.8	1.4	<5	19	70	0.8
Nev., Carson City [c]	1.82	0.6	1.4	<5	15	50	0.8
N. J., Trenton [c]	2.36	0.5	1.3	<5	11	65	1.2
N. Mex., Albuquerque	1.92	0.8	1.5	<5	13	45	0.7
N. Y., New York	1.74	0.8	1.6	<5	15	100	0.7
N. C., Charlotte [c]	1.75	0.7	1.1	<5	25	55	NA
N. Dak., Fargo [c]	1.39	0.8	1.4	<5	16	90	1.0
Ohio, Cleveland	1.95	0.6	1.6	<5	13	85	0.5
Okla., Oklahoma City	1.78	0.6	1.2	<5	14	45	[b] 2.2
Oreg., Portland [c]	2.05	0.4	1.5	<5	13	60	0.6
Pa., Pittsburgh	2.17	0.6	1.5	<5	17	85	0.7
S. C., Charleston [c]	1.69	0.5	1.2	<5	17	70	NA
S. Dak., Sioux Falls [d]	1.62	0.7	1.8	<5	19	90	0.5
Tenn., Memphis	1.60	0.6	1.2	<5	20	50	[b] 1.9
Tex., Austin	1.95	0.5	1.1	<5	10	35	[b] 1.5
Utah, Salt Lake City	1.42	0.6	1.5	<5	18	110	0.7
Vt., Burlington	1.56	0.6	1.6	<5	16	100	0.7
Va., Norfolk [c]	2.19	0.5	1.1	<5	15	60	[b] 2.0
Wash., Seattle	1.90	0.6	1.5	5	22	105	0.7
W. Va., Charleston [c]	1.90	0.6	1.2	<5	23	60	NA
Wisc., Milwaukee	2.50	0.7	1.5	<5	11	80	0.5
Wyo., Laramie	1.63	0.6	1.5	<5	18	70	[e] 1.0
Institutional Average	1.93	0.6	1.4	<5	17	75	0.7
Maximum	2.58	0.9	1.8	5	31	150	1.2
Minimum	1.39	0.4	1.1	<5	10	35	0.4

[a] NA indicates no analysis performed.

[b] Total radium.

[c] Average ^{90}Sr and ^{137}Cs concentrations are minimum values. Station began operation in June 1964 or later. Peak values for these nuclides were observed during the second quarter of 1964.

[d] Data for this station based on December 1964 sample only.

[e] Average based on radium-226 only.

Table 4. Annual average calcium, potassium, and radionuclide intakes as determined by institutional total diet sampling, 1964

Location of institution	Total wgt. (kg./day)	(grams per day)		Radionuclide concentrations, pCi/day			
		Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Ala., Montgomery [c]	2.23	1.1	2.4	10	30	105	[a] NA
Alaska, Palmer	1.50	0.8	2.1	10	30	155	1
Ark., Little Rock	1.79	1.1	2.1	5	47	110	[b] 3.5
Calif., Los Angeles	1.79	1.2	2.8	5	17	90	1
Colo., Denver	2.42	1.5	3.7	10	31	150	2
Conn., Hartford [c]	1.86	1.2	2.8	5	20	150	1
Del., Wilmington	1.88	1.5	3.0	5	29	175	1
Fla., Tampa	2.16	1.5	2.6	5	29	295	[b] 4.3
Ga., Atlanta	2.01	1.0	2.3	10	38	120	[b] 3.4
Hawaii, Honolulu	1.71	0.8	2.3	10	18	125	2
Idaho, Idaho Falls	1.94	1.3	3.0	5	46	240	1
Ill., Chicago [c]	1.57	1.1	2.4	5	21	140	1
Ind., Indianapolis [c]	1.69	1.3	2.6	5	22	110	1
Iowa, Des Moines [c]	2.56	1.9	3.2	10	47	145	NA
Kans., Wichita [c]	2.12	1.3	2.7	5	27	100	NA
Ky., Louisville [c]	1.95	1.4	2.2	5	40	80	NA
La., New Orleans	2.58	1.6	3.5	10	67	225	[b] 6.3
Maine, Portland	2.29	1.6	3.4	5	45	270	1
Md., Baltimore [c]	1.96	1.4	2.5	10	35	120	NA
Mass., Boston	1.69	1.2	2.6	5	34	260	1
Mich., Detroit [c]	2.01	1.4	2.8	5	23	155	1
Minn., Minneapolis	1.74	0.9	2.5	10	32	160	1
Miss., Columbia	1.97	1.8	2.5	10	62	245	[b] 6.1
Mo., St. Louis	2.43	1.6	3.4	15	48	150	2
Mont., Helena	2.02	1.0	2.4	10	30	190	1
Nebr., Omaha	2.03	1.6	2.9	5	39	140	2
Nev., Carson City [c]	1.82	1.2	2.6	5	28	90	1
N. J., Trenton [c]	2.36	1.1	3.1	5	26	150	3
N. Mex., Albuquerque	1.92	1.6	2.9	5	24	80	1
N. Y., New York	1.74	1.4	2.8	0	27	170	1
N. C., Charlotte [c]	1.75	1.2	1.9	5	45	95	NA
N. Dak., Fargo [c]	1.39	1.1	2.0	5	22	125	1
Ohio, Cleveland	1.95	1.2	3.2	5	26	170	1
Okla., Oklahoma City	1.78	1.1	2.1	5	24	75	[b] 4.2
Oreg., Portland [c]	2.05	0.9	3.0	5	26	125	1
Pa., Pittsburgh	2.17	1.3	3.2	5	36	185	2
S. C., Charleston [c]	1.69	0.8	1.9	5	29	120	NA
S. Dak., Sioux Falls [d]	1.62	1.1	2.9	5	31	145	1
Tenn., Memphis	1.60	1.0	2.0	5	32	80	[b] 3.0
Tex., Austin	1.95	1.0	2.1	5	20	70	2.9
Utah, Salt Lake City	1.42	0.9	2.2	5	26	155	1
Vt., Burlington	1.56	1.0	2.5	5	25	155	1
Va., Norfolk [c]	2.19	1.1	2.4	10	34	130	[b] 4.3
Wash., Seattle	1.90	1.2	2.8	10	43	200	1
W. Va., Charleston [c]	1.90	1.2	2.3	5	43	115	NA
Wisc., Milwaukee	2.50	1.5	3.2	5	24	170	1
Wyo., Laramie	1.63	1.0	2.4	5	30	115	[e] 2
Institutional Average	1.93	1.2	2.6	5	33	145	1
Maximum	2.58	1.9	3.7	15	67	295	3
Minimum	1.39	0.8	1.9	0	17	75	1

[a] NA indicates no analysis performed.
[b] Total radium.
[c] Average ^{89}Sr and ^{137}Cs concentrations are minimum values. Station began operation in June 1964 or later. Peak values for these nuclides were observed during the second quarter of 1964.
[d] Data for this station based on December 1964 sample only.
[e] Average based on radium-226 only.

are within the FRC Range I (*3*), which indicates that periodic confirmatory surveillance is the recommended action.

The strontium-90 annual average daily intake ranged from 17 to 67 pCi/day and the overall average daily intake was 33 pCi/day. These results fall within FRC Range II (*3*), indicating that quantitative surveillance and routine control is the recommended action.

Cesium-137 daily intakes ranged from 70 to 295 pCi/day with an average of 145 pCi/day. At the same time radium-226 daily intakes averaged 1 pCi/day.

During 1964, both barium-140 and iodine-131 concentrations were below detectable levels.

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 2, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July-September 1963	*March 1964*
October-December 1963	*July 1964*
January-March 1964	*October 1964*
April-June 1964	*January 1965*
July-September 1964	*April 1965*

RADIONUCLIDES IN DIETS FOR TEENAGERS FEBRUARY-NOVEMBER 1964

Division of Pharmacology, Food and Drug Administration

It has been estimated that among all age groups 16 to 19-year-old males need more food daily than any other segment of the U.S. population (*1*). Because of this, the Food and Drug Administration (FDA) chose this age group for a test of the maximum radionuclide intake of all population groups. As a basis for the test, the food plan used was that recommended by the U.S. Department of Agriculture (USDA) for a nutritionally adequate diet at moderate cost level for boys 16–19 years of age (*2*).

The FDA study of radionuclides in diets for teenagers was begun on a pilot basis in May 1961 in the Washington, D.C. area. Since then, the program has been expanded to include 8 other cities—San Francisco, Minneapolis, St. Louis, Atlanta, Denver, Boston, Dallas, and Seattle.

By selecting the 16 to 19-year-old male, who daily needs 3,600 calories with adequate protein, minerals, and vitamins, compared with 3,200 calories and smaller amounts of nutrients needed by the "standard" man, the radionuclide intake in U.S. diets can be conservatively estimated. For the purposes of the sampling program, amounts of the foods selected from the 11 food groups of the USDA plan were proportioned according to the 1965 Household Food Consumption Survey (*3*).

Sampling and analytical procedures

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. Quarterly samples of these items, covering a two-week consumption period, were purchased from national food chain stores. Efforts were made to locate the sources of the food items and to arrange representation in the samples on the broadest possible geographical basis.

The foods were prepared by professional dietitians in diet kitchens at each city in a manner comparable to domestic preparation procedures. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Representative portions of the foods (including about 8 liters of drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium–90 and cesium–137 at the nearest FDA District laboratory. Strontium–90 was separated radiochemically and its concentration determined by beta counting. Gamma spectrometry was employed for cesium–137 analysis.

Results

The quarterly strontium–90 and cesium–137 concentrations and daily intakes for the recommended diet are presented in tables 1

Table 1. Strontium-90 concentrations and intakes in the total diet, 1964

Sampling locations		February 1964		May 1964		August 1964		November 1964	
		pCi/kg	pCi/day [a]	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Calif:	San Francisco	7.0	26	7.0	26	6.3	24	5.9	22
Colo:	Denver	12	45	14	52	11	40	7.2	27
D. C:	Washington	17	63	15	57	11	42	[b] NS	NS
Ga:	Atlanta	25	92	28	103	20	75	21	79
Mass:	Boston	[c] NA	NA	7.0	26	17	63	8.4	32
Minn:	Minneapolis	13	50	12	47	10	38	8.8	33
Mo:	St. Louis	10	38	15	56	18	67	7.6	29
Texas:	Dallas	13	48	14	52	11	41	10	3.8
Wash:	Seattle	13	48	17	65	13	48	14	53
Average		14	53	14	53	13	53	11	41

[a] Intakes based on the consumption of 3.76 kg food and drink for the 16–19-year-old male.
[b] NS indicates no sample found.
[c] NA indicates no analysis performed.

Table 2. Cesium-137 concentrations and intakes in the total diet, 1964

Sampling locations	February 1964		May 1964		August 1964		November 1964	
	pCi/kg	pCi/day [a]	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Calif: San Francisco	62	237	62	237	34	132	42	152
Colo: Denver	70	[illegible]	84	316	59	222	57	139
D. C: Washington	82	[illegible]	97	284	60	222	[b] NS	NS
Ga: Atlanta	81	302	115	470	51	192	83	213
Mass: Boston	119	447	108	408	92	346	96	351
Minn: Minneapolis	103	287	57	227	102	384	69	229
Mo: St. Louis	67	233	85	313	39	147	85	297
Tex: Dallas	[c] NA	NA	58	211	40	150	96	211
Wash: Seattle	64	241	104	391	86	222	57	265
Average	82	309	90	336	70	260	67	233

[a] Intakes based on the consumption of 3.76 kg food and drink for the 16–19-year-old male.
[b] NS indicates no sample found.
[c] NA indicates no analysis performed.

and 2. Individual station values for the quarter ending in the month shown are given along with network averages for the nine cities sampled.

Strontium-90

The network average daily strontium-90 intakes for March 1961 through November 1964 are presented in figure 1. Ranges are shown where appropriate. Prior to May 1962, only one location was sampled. The average strontium-90 intake in the diet is seen to have increased steadily from 14 pCi/day in May 1961 to 63 pCi/day in February 1964, after which a decrease is noted. The figure also shows that strontium-90 contamination resulting from the USSR and USA atmospheric tests of 1961 and 1962 has peaked broadly over the years 1963 and 1964; however, a downward trend is apparent. The peak average value in February 1964 represents about one-third of the top of Range II (200 pCi/day) as recommended by the Federal Radiation Council (4).

The dotted lines in figure 1 represent the daily intakes observed in Atlanta, Georgia, and San Francisco, California. Comparison of these values with the observed ranges of daily strontium-90 intakes indicates that the Atlanta

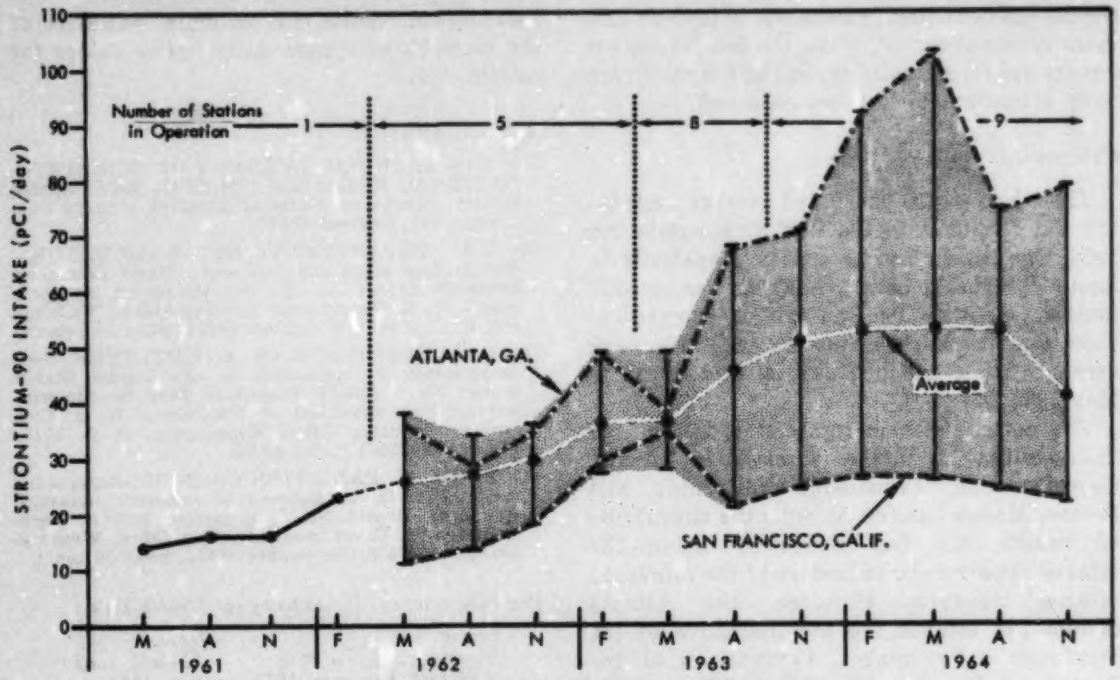

Figure 1. Averages and ranges of daily strontium-90 intake in FDA teenage standard diet

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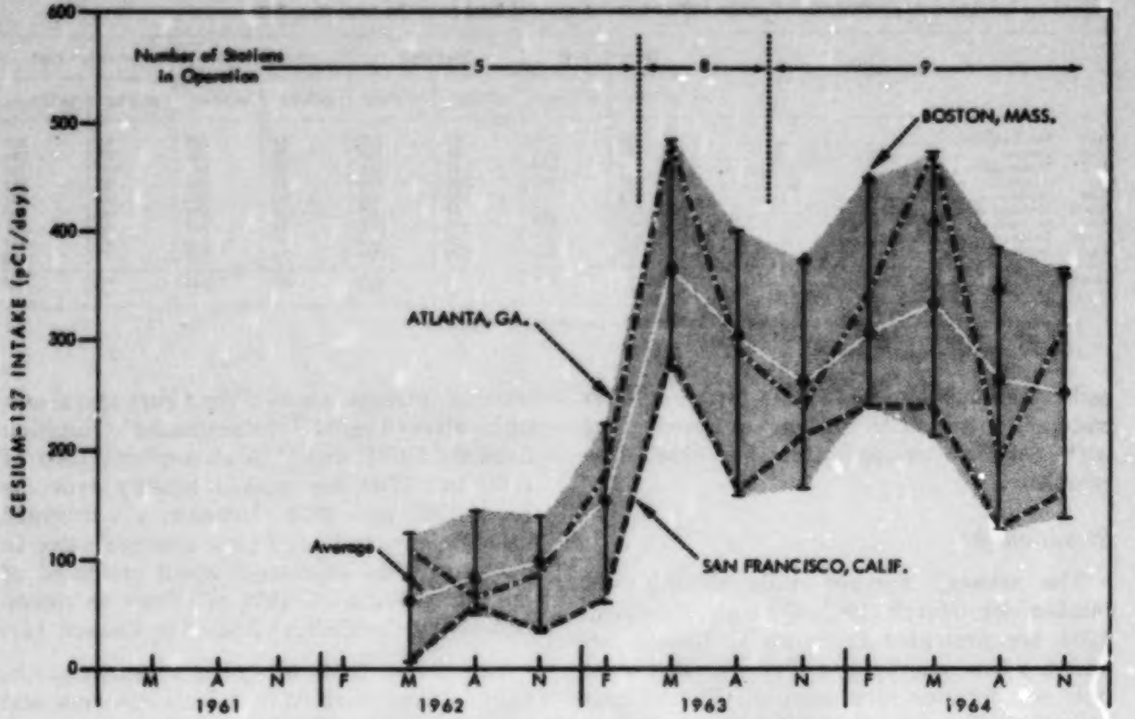

Figure 2. Averages and ranges of daily cesium-137 intake in FDA teenage standard diet

results are consistently comparable to the maximum values observed, while the San Francisco results are consistently typical of the minimum daily strontium-90 intakes observed.

Cesium-137

Table 2 gives the calculated average cesium-137 daily intakes in the diet by quarters for 1964. The results are presented graphically in figure 2. The general trend in cesium-137 intakes is downward, and can be expected to become more clearly defined in 1965. The peak average value, 366 pCi/day, was observed in May 1963.

The dotted lines in figure 2 represent the daily cesium-137 intakes observed in Atlanta, Georgia; San Francisco, California; and Boston, Massachusetts. As with the strontium-90 results, the San Francisco cesium-137 intakes appear to be indicative of the minimum intakes observed. However, the Atlanta cesium-137 intakes are not indicative of the maximum daily intakes. Comparison of the Boston results since November 1963 suggests that Boston results may be more indicative of the network maximum daily intake values for cesium-137.

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(*2*) U.S. DEPARTMENT OF AGRICULTURE. Family food plans and food costs, Home Economics Research Report No. 20, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (November 1962), price 35 cents.

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, Report No. 1 (1955), Household Food Consumption Survey, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (December 1956), price $1.25.

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
May 1961–August 1962	*January 1963*
May 1962–February 1963	*June 1963*
May 1963–November 1963	*April 1964*

ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CONNECTICUT STANDARD DIET, MARCH 1963-DECEMBER 1964

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. These analyses included strontium-89, strontium-90, and gamma emitting radionuclides.

The standard diet was selected to represent the food intake of an 18-year-old boy for one day (table 1). The total weight of the complete blended diet averaged 3 kilograms, including milk and dairy products. Any raw fruit or vegetables used were washed before blending.

Table 1. Representative kinds and amounts of foods included in standard diet

Bread, white—8 slices
Butter, ½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks.
Cookies—4
Cottage Cheese—⅓ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice Cream—½ pint
Lettuce, washed—4-5 leaves
Milk—3 cups
Oatmeal, uncooked—43 grams
Orange—1
Peanut Butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Analytical procedure

Gamma emitting radionuclide concentrations were determined using a 2-kilogram sample portion. The sample portion was counted in a low-background shield employing a 4 x 4-inch sodium iodide crystal detector and a 400-channel pulse height analyzer. The resultant gamma ray spectrum was reduced to individual radionuclide concentrations using a matrix procedure.

Strontium-89 and strontium-90 analyses were performed on a sample portion which was dried and ashed. Individual strontium results were determined by chemical separation subsequent to counting a low-background Geiger-Mueller counter utilizing a thin-window, gas-flow counting chamber.

Results and discussion

Table 2 presents the analytical results for the Connecticut standard diet from March 1963 through December 1964. Radionuclides other than those listed were observed, but in most cases the concentrations were equal to or less than the counting error. In a few cases, the concentrations were slightly higher than the

Table 2. Radionuclide concentrations in teenage standard diet

Month	Potassium (g/kg)	Strontium-89 (pCi/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
1963				
March	2.3	5.0	8.7	60
July	2.2	15.9	13.7	80
August	2.4	15.5	13.4	130
September	2.3	10.3	15.6	120
October	2.2	4.1	16.4	100
November	2.4	4.4	13.1	110
December	2.3	3.4	17.3	140
1964				
January	2.3	4.6	15.1	140
February	2.4	<3.0	13.2	110
March	2.2	<3.0	16.4	150
April	2.4	<3.0	14.0	160
May	2.4	<3.0	11.9	90
June	2.1	<3.0	16.4	120
July	2.0	<3.0	15.1	130
August	2.2	<3.0	19.2	110
September	2.4	<3.0	15.4	100
October	2.4	<3.0	14.5	100
November	2.1	<3.0	12.0	80
December	2.3	<3.0	12.4	70

counting error. These included ruthenium–106 in three samples (counting error ±40 pCi/kg with the matrix procedure used) and zirconium-niobium–95 in one sample (counting error ±10 pCi/kg).

Results representing the total daily intake for the radionuclides observed are presented in table 3. In order to evaluate general trends the strontium–90 and cesium–137 daily intakes are plotted as a function of time in figure 1.

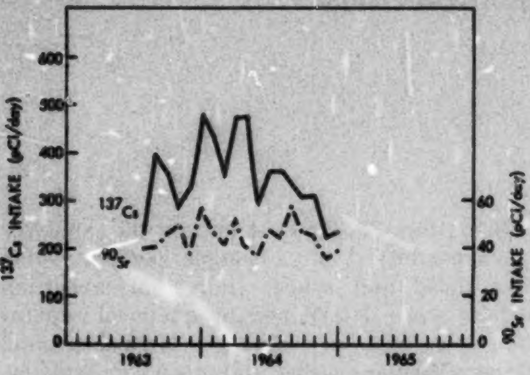

Figure 1. Radionuclide intake in Connecticut standard diet

The cesium–137 intake shows seasonal variation, with a maximum in the spring; the strontium–90 daily intake values have remained fairly uniform from March 1963 through December 1964.

Table 3. Daily radionuclide intakes in Connecticut standard diet

Month	Potassium (g/day)	Strontium–89 (pCi/day)	Strontium–90 (pCi/day)	Cesium–137 (pCi/day)
1963				
March	7.6	16.7	38.9	200
July	6.4	46.1	39.6	220
August	7.2	43.2	30.9	390
September	6.9	30.8	46.4	350
October	6.5	12.2	48.7	280
November	6.8	12.4	37.2	320
December	7.7	11.3	57.6	480
1964				
January	7.1	14.2	46.7	430
February	7.5	<3.0	41.3	350
March	6.8	<3.0	50.3	470
April	7.0	<3.0	40.6	470
May	7.6	<3.0	37.6	290
June	6.1	<3.0	47.6	360
July	5.8	<3.0	42.9	370
August	6.4	<3.0	55.9	330
September	7.3	<3.0	45.7	310
October	7.5	<3.0	45.2	310
November	6.2	<3.0	35.6	220
December	7.2	<3.0	38.9	230

ESTIMATES OF THE CONCENTRATIONS OF STRONTIUM-89, STRONTIUM-90, AND CESIUM-137 IN MILK AS A FUNCTION OF TIME AFTER AN ACUTE LOCALIZED CONTAMINATING EVENT

Report of Ad Hoc Panel on Environmental Factors,[1] Federal Radiation Council

The Federal Radiation Council, in developing recommendations[2] for protective actions applicable to strontium–89, strontium–90 and cesium–137, convened this Panel to examine various environmental problems related to human exposure that could occur subsequent to an acute localized contaminating event involving any of the three radionuclides. Fresh fluid milk was identified as the most important problem area because of its unique potential relative to other pathways to transmit high levels of exposure to large segments of the public in short time intervals. Particular attention, therefore, was directed to the transmission of strontium–89, strontium–90 and cesium–137 to man through the pasture-cow-fresh milk pathway of contamination.

This report primarily provides a quantitative assessment of various factors involving radioactive contamination of pasture and milk subsequent to an acute contaminating event for which prompt action may be necessary. As such quantitative assessment must be predicated on a given set of environmental factors, the following conditions of environmental contamination and milk consumption were assumed:

1. The contaminating event is a single acute intrusion involving a localized area in the order of hundreds of square miles;
2. the deposition will occur within a period of one day;
3. the previous cumulative levels of contamination in the soil or on pasture with these radionuclides are negligible relative to the levels resulting from the contaminating event;
4. the deposition occurs in a locale in which pasturage provides the major portion of the roughage consumed by the dairy cattle and during a time period when pasturage is at a normal seasonal rate of vegetative growth;
5. residents of the involved area daily consume an average of one liter of milk produced from the contaminated pasture;
6. the physical and chemical properties of strontium–89, strontium–90 and cesium–137 are the same as found in worldwide fallout.

With these assumptions, estimates are made of the theoretical concentrations and changes in concentration that can be expected to occur for each nuclide in fresh milk as a function of time following the acute contaminating event. Corresponding estimates also are made of the projected intake[3] of these nuclides by a human population whose total milk supply consists of the contaminated milk. The theoretical potential of certain protective actions to reduce the projected intakes also is considered. The estimates, for the most part, are derived from data from experimental work (appendix 1). Computations also were made from data from the PHS pasteurized milk surveillance network (appendix 2) and were in basic agreement with those derived experimentally.

Experiments were conducted with small groups of cows which were given constant daily activities of radionuclides, and the resultant levels of these nuclides were observed in milk (appendix 1). The graphs in figures 1 and 2 present curves which characterize the secretion of strontium–89, strontium–90, and

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[1] The Panel contributing to this report is as follows:
Arthur H. Wolff (Chairman)
George F. Fries
Joseph Rivera
Jared J. Davis
F. W. Lengemann
Wayne E. Hanson
Benjamin H. Bruckner
John Harley
Tommy F. McCraw
Frank B. Hungate
Donald G. Watson

[2] Federal Radiation Council, Report No. 7.

[3] Projected intake as used in this report is the accumulated intake of the radionuclide that would be received in the future by individuals in the population group from the contaminating event under the conditions cited.

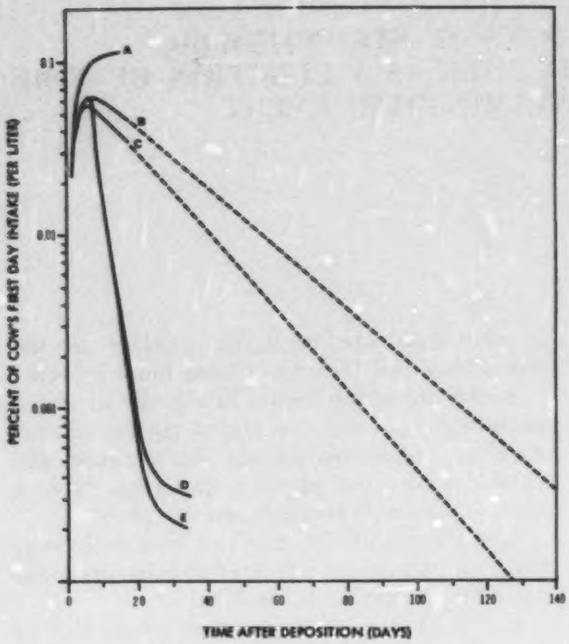

Figure 1. Concentration of strontium–89 and strontium–90 in milk of cows

cesium–137 into milk following the ingestion of these nuclides by cows as a function of time. These graphs are based upon the experimental data and equations developed in appendix 1. Curve A in figure 1 depicts the transfer of radiostrontium into milk based on experimental conditions in which cows ingest equal activities of radiostrontium daily. Curves B and C are computed to show the concentrations of strontium–90 and strontium–89, respectively, in milk following a single contaminating event on pasture assuming the cattle remain on the contaminated pasture. Curves D and E reflect the corresponding concentrations of strontium–90 and strontium–89 in milk following a single contaminating event assuming the cows are removed from the contaminated pasture at the time of maximum concentration of these nuclides in the milk (see Appendix 1 for derivation).

Curve A in figure 2 illustrates the appearance of radiocesium in milk of cows based on experimental results following daily equal ingested doses of cesium–137, Curve B is computed to show the concentration of cesium–137 in milk following a single contaminating event with the cows remaining on pasture, and Curve C shows the concentrations of cesium–137 following a single contaminating event if the cows are removed from pasture at time of maximum concentration of cesium–137 in the milk.

Those curves which relate to single contaminating events reflect a "disappearance half-time" from pasture of a little over two weeks for strontium–90 and cesium–137 and about thirteen days for strontium–89 (a few days shorter reflecting its shorter radioactive half-life).

Selected data from the Public Health Service Pasteurized Milk Network were also used to estimate the disappearance half-times of these nuclides under fallout conditions (appendix 2). Criteria were established to identify increased levels in milk contamination that probably resulted from single contamination events. These data suggest disappearance half-times of 11 to 13 days for strontium–89, 11 to 15 days for strontium–90 and 10 to 15 days for cesium–137.

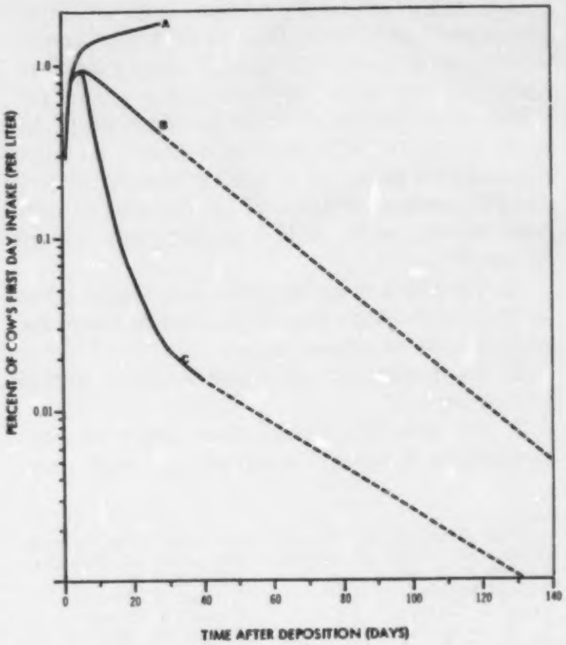

Figure 2. Concentration of cesium–137 in milk of cows

It is noted that the values for the disappearance half-times of these radionuclides from pasture are quite short relative to their physical half-lives. This is due to a combination of factors which diminish the contamination levels available to the grazing cow. The more important factors include removal from foliage by wind and rain and the normal cycle of plant growth combined with the grazing practices of dairy cattle. Based upon these half-times and assuming that the cattle remain on the contaminated pasture, the milk levels of the radionuclides of interest can be expected to decline to less than 1–2 percent of their maximum levels within a period of 3–4 months following the acute contaminating event. Therefore, it is suggested that the 100-day period following that contaminating event represents a reasonable approximation of the period of "total" projected intake.

The computations from appendix 1 are summarized in the tables that follow. In the tabular presentations T_o represents the time at which the contaminating event occurs and T_m the time required, in days, after the contaminating event for the maximum concentration of each nuclide to be reached in milk. Table 1 summarizes T_m for each nuclide.

Table 1. Time after deposition for maximum milk levels to occur

Nuclide	Tm
Strontium-89	7 days
Strontium-90	7 days
Cesium-137	6 days

Table 2 presents the total projected cumulative intake as a ratio or multiple of the maximum concentration. For example, if the maximum concentration of strontium–89 were 1 μCi/liter of milk and an individual consumes 1-liter of milk per day from the affected area for about 100 days, his total projected intake of strontium–89 would be about 27 μCi. These ratios may be useful in predicting the magnitude of a contamination problem once the maximum concentration has been determined.

Table 2. Ratios of total human projected intake to human intake at time of maximum concentration in milk

Nuclide	Ratio
Strontium-89	27 times the maximum value
Strontium-90	33 times the maximum value
Cesium-137	32 times the maximum value

As previously indicated, if the cows remain on the contaminated pasture for about 100 days subsequent to the contaminating event, almost the total projected intake will have ensued. The actual periods calculated for the maximum milk concentration of each nuclide to be reduced by factors of 10 and 100 under conditions of continuous grazing on contaminated pasture are presented in table 3.

Table 3. Time required for milk concentrations to be reduced by factors of 10 and 100 if cows remain on contaminated pasture

Nuclide	Time for reduction factor of:	
	10	*100*
Strontium-89	32 days	94 days
Strontium-90	67 days	124 days
Cesium-137	67 days	125 days

Table 4 lists the time periods required for the milk concentration to be reduced by factors of 10 and 100 after the cows are shifted to uncontaminated feed. The time periods for reduction are appreciably shorter as compared to the corresponding estimates in table 3 indicating the effectiveness of the protective action afforded by shifting the cows off the contaminated feed.

Table 4. The time required for milk concentrations to be reduced by factors of 10 and 100 after cows are shifted to uncontaminated feed

Nuclide	Time for reduction factor of:	
	10	*100*
Strontium-89	6 days	13 days
Strontium-90	6 days	14 days
Cesium-137	8 days	49 days

Table 5. The projected total intake avoided by shifting cattle to uncontaminated feed as related to the time the action is taken

Percent of projected total intake avoided	Approximate time after T_0 for shift to be made		
	^{89}Sr	^{90}Sr	^{137}Cs
	(days)	(days)	(days)
50	13	17	14
75	6	7	5
90	2	2	2
99	<1	<1	<1

Table 5 summarizes the effectiveness of the protective action of shifting cows to uncontaminated feed as a function of the time interval between the contaminating event (T_0) and the time that the action is instituted. These estimates show that in order for this protective action to effect at least a 50 percent reduction of projected intake, it must be instituted very soon (within a matter of days) after the contaminating event.

The calculations summarized in table 5 assume that individuals in the population are consuming the milk produced in the affected area as their exclusive milk supply before and after the "shift." An even more effective protective action, but one probably having more adverse impact on dairy marketing, would be to ban entirely for human consumption the milk from the affected area. This action also must be instituted early if its effectiveness is to be optimal; 10 to 20 percent of the total projected intake will have found its way into the milk produced in the contaminated area within 4–6 days after T_0.

The approximate nature of the preceding data and estimates must be emphasized. They primarily reflect the mechanism of transfer of these nuclides from pasture to milk following deposition of the radionuclides under the previously specified assumptions. The estimates do *not* pertain to the more persistent contamination problems resulting from residual contamination of soil, root mats or stem bases, or of crops other than pasture nor do they pertain to unusual conditions of vegetative growth. The patterns of milk contamination may be different if environmental conditions quite unlike those assumed should prevail.

The Panel also considered the exposure potential of food other than fresh milk (appendices 3 and 4) and concluded that if a contaminating event involves a milkshed, particularly one in which dairy cows are on pasture, milk will probably be the major and limiting mode of transmission for all three nuclides and generally the concentrations found in milk should provide valid bases for considering control measures in other foods as well as milk. Because the nuclides of interest have relatively long physical half-lives, their contamination potential via foods other than milk cannot be ignored. Foods other than fresh milk may be additionally important pathways of human exposure or, with little or no contamination of pasture involved, the most significant pathways of human exposure. The agricultural, geographical and radiobiological variables are too numerous and complex to allow any quantitative estimates or predictions of the relative importance of foods other than fresh milk in terms of their projected intakes. However, the marketing practices for most foods, as compared to fresh milk, are such that considerably more time will be available to assess any contamination problems and to implement any control procedures that may be warranted.

Appendix 1. Radionuclide concentrations in milk following a contaminating event involving pasture

J. J. Davis, F. W. Lengemann, and G. F. Fries

The purpose of this paper is to develop the equations which describe the concentration of strontium–89, strontium–90 and cesium–137 in milk from cows grazing a pasture that has been contaminated by an acute event. After developing the basic equations, it is possible to derive a number of estimates describing the radionuclide intake by people consuming milk from these cows.

The assumptions concerning the contaminating event were:

1. The deposition time is short (hours to days);
2. The chemical and physical properties are the same as found in worldwide fallout;
3. The deposition is on pasture supplying feed for dairy cows;
4. Background and cumulative soil levels are negligible; and
5. Human consumption of milk is one liter per day.

There are three factors that affect the radionuclide concentration in milk following a single contaminating event. These are: the rate of nuclide secretion into milk as a result of the initiation of continuous nuclide intake by the cow; the decreasing rate of nuclide intake by the cow due to pasture "losses"; and the decreasing rate of radionuclide intake by the cow due to radioactive decay.

In general, data from environmental survey studies were not appropriate for the purposes of this paper because most of the depositions that have occurred as a result of nuclear testing were of a long duration and can not be considered single events. For this reason the equations describing the milk concentrations of radionuclides were derived from laboratory tracer studies. When possible, data from environmental studies were examined to be certain that there were no important disagreements with the tracer studies.

The rate of radiostrontium transfer to milk under conditions of continuous intake was estimated from the average of 5 cows which were given twice-daily doses of strontium–85 for a period of about 15 days (*1*). One cow received the isotope for a period of 65 days and it was found that a complete equilibrium is not established within this period. By graphic analysis it was found that the basic curve (A of figure 1) for radiostrontium transfer to milk could be described by the equation:*

$$(1) \qquad A = 0.1e^{0.008t}(1 - e^{-0.26t})$$

Similarly, the rate of radiocesium transfer to milk under conditions of continuous intake was estimated from the average of 7 cows which were given twice-daily doses of cesium–137 for a period of 35 days (*1, 2*). Graphic analysis of the basic equation for the appearance of radiocesium in cows' milk (curve A of figure 2) gave the equation:

$$(2) \qquad A = 1.3e^{0.01t}(1 - e^{-0.41t})$$

Neither of the basic equations reflect the decreasing nuclide intake by cows which would occur as a result of "vegetative losses" and radioactive decay. "Vegetative losses" includes all processes which affect the concentration of the nuclides per unit dry matter of pasture. This includes such factors as weathering, dilution by new growth, and removal of the nuclides by the cow's consumption.

Data of Milburn and Taylor (*3*) indicate that the half-time of radiostrontium on pasture grass was about 14 days. Data of Ward (*4*) for iodine–131 and cesium–137 content of the milk of a group of cows show that the iodine is lost from pasture grasses with a half-time of 17.6 days, while cesium showed a rate of loss with a half-time of about 13 days. Therefore, it seemed reasonable to use the value of 14 days as an estimate of the time for the concentration of radioisotopes on pasture grass to decrease to one-half of the initial value. To account for this factor it is necessary to multiply the basic equations by $e^{-0.05t}$. Because of the long radioactive half-lives of strontium–90 and cesium–137, the decrease in intake of these nuclides by the cow over the period of interest will be insignificant.

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* In all equations in this paper, A is the radionuclide concentration of milk in percent of intake by the cow on the first day per liter of milk and t is time in days after deposition.

The equation expressing strontium–90 content of milk of cows on contaminated pasture following a single deposition then becomes:

$$A=0.1e^{0.008t}(1-e^{-0.26t})(e^{-0.05t}) \tag{3}$$

This equation is plotted as curve B of figure 1. The broken line indicates extension of the calculation beyond the limits of the experimental curve.

Equation (3) is also applicable to strontium–89 if a further correction is made for the short physical half-life (50.5 days) of this radionuclide. Its equation becomes:

$$A=0.1e^{0.008t}(1-e^{-0.26t})(e^{-0.05t})(e^{-0.014t}) \tag{4}$$

This equation has been plotted as curve C of figure 1.

When pasture losses of cesium are added, equation (2) modifies to:

$$A=1.3e^{0.01t}(1-e^{-0.41t})(e^{-0.05t}) \tag{5}$$

This equation is plotted as curve B in figure 2.

Another parameter important for the purposes of this paper is the rate of decrease of the radionuclide concentrations of milk if the cows are removed from the contaminated pastures to an uncontaminated feed source. There is no information available that is directly applicable to this situation. However, the declining phases of single dose tracer experiments should be fairly comparable and data from this source have been used.

Milk concentration curves for 30 cows given a single dose of radiostrontium were averaged (*1, 5, 6, 7*). Such a curve takes about 24 to 48 hours to reach a peak and then declines as an exponential function. The equation for the decline is:

$$^{90}\text{Sr (percent dose/liter)} = 0.054e^{-0.37t}+0.000375e^{-0.01t} \tag{6}$$

The equation for strontium–89 would be similar except that a factor must be included for radioactive decay. The equation for strontium–89 then becomes:

$$^{89}\text{Sr (percent dose/liter)} = (0.054e^{-0.37t}+0.000375e^{-0.01t})(e^{-0.014t}) \tag{7}$$

These equations have been plotted in figure 1 as curves D and E and represent milk concentrations of strontium–90 and strontium–89, respectively.

Milk concentration curves of 11 cows given a single dose of radiocesium were averaged. The data represented cows followed for a period of from 9 to 30 days (*1, 7, 8, 9*). The equation for the declining phase of the curve was:

$$^{137}\text{Cs (percent dose/liter)} = 0.234e^{-0.37t}+0.081e^{-0.17t}+0.011e^{-0.02t} \tag{8}$$

The equations describing the milk concentration of the various radionuclides—Nos. (3), (4), (5)—show that for cows on a pasture contaminated over a relatively short length of time, the concentration of cesium–137 in milk will reach a peak at about 6 days. For both strontium isotopes the peak will occur at about 7 days. After reaching a peak, the radionuclide concentrations begin a decline which has a half-time of about 14 days. The nuclide concentration of milk at the time of the maximum will be 0.94, 0.064 and 0.057 percent of the cow's intake on the first day for cesium–137, strontium–90, and strontium–89, respectively.

In developing the equations, it was necessary to express the concentration of radionuclides in milk as a function of the cow's intake of radionuclides. In practice, the cow's intake on pasture cannot be measured. However, the relationships between measured concentrations of radionuclides in milk and the projected intakes by man are valid regardless of the units used.

The projected radionuclide intake of a person drinking one liter of milk per day from cows kept on contaminated pasture can be calculated by integrating equations Nos. (3), (4) and (5) from $t = 0$ to $t = \infty$. For strontium–89, strontium–90, and cesium–137, the projected radionuclide intake by man will be 1.55, 2.11, and 30 percent of the cows' intake on the first day, respectively. If these values are divided by the corresponding maximum values of radionuclide concentration in milk, the projected intake by man (from $t = 0$ to $t = \infty$) would be 27, 33, and 32 times the maximum concentrations in milk, respectively.

The percentage of the total projected intake by a person that will occur by the time of maximum concentration of radionuclides in milk can be estimated by integrating these equations between $t = 0$ and $t = 6$ days for cesium-137 and $t = 0$ and $t = 7$ days for strontium-89 and strontium-90. It was estimated that 16, 21, and 16 percent of the total projected radionuclide intake by a person for cesium-137, strontium-89, and strontium-90, respectively, will occur by the time the milk values are maximized.

If the cows are maintained on pasture, the equations (3), (4), and (5) can be used to calculate the time for the radionuclide concentration in milk to be reduced by a factor of 10 and 100 due to pasture losses and radioactive decay. For simplified calculating, it was assumed that the value $(1-e^{-kt})$ had approached close enough to 1 to be disregarded. The results are shown in table 6.

Table 6. Time required to reduce the radionuclide concentration of milk when the cows are not removed from pasture

Nuclide	Reduction factor, days	
	for 10-fold reduction	for 100-fold reduction
Strontium-89	52	94
Strontium-90	67	124
Cesium-137	67	125

In order to predict what would occur if cows are changed to uncontaminated feed, it is necessary to evaluate equations (6), (7), and (8). The time required to reduce the radionuclide concentration in milk by factors of 10 and 100 is shown in table 7. These values were obtained by graphical analysis.

Table 7. Time required to reduce the radionuclide concentration of milk after the cows are removed from pasture

Nuclide	Reduction factor, days	
	for 10-fold reduction	for 100-fold reduction
Strontium-89	6	13
Strontium-90	6	14
Cesium-137	8	49

If the equations (6), (7), and (8) are integrated from 0 to ∞, the projected radionuclide intake by man (at one liter of milk/day) will equal 2.86, 3.36, and 5.1 times the concentration in milk at the time of the shift to uncontaminated feed for strontium-89, strontium-90, and cesium-137, respectively. The use of these values, together with the corresponding maximum concentration values in milk and the projected intake up to the time of maximum concentration, make it possible to estimate the projected intake that would occur if the cows were shifted to uncontaminated feed at the time of maximum concentration. For strontium-89 this value will be approximately 32 percent of the total projected intake when the cows are not shifted from the contaminated pasture. Similar values for strontium-90 and cesium-137 are 26 percent and 31 percent.

By similar types of calculations, it is possible to estimate the time that cows must be shifted to uncontaminated feed in order to avoid various percentages of the projected intakes. A summary of these values is presented in table 8.

Table 8. Approximate time after deposition for a shift to be made in order to avoid specified percentages of the total projected intake by man

Projected intake avoided	Cesium-137	Strontium-89	Strontium-90
(%)	(days)	(days)	(days)
50	14	13	17
75	5	6	7
90	2	2	2

Appendix 2. Preliminary estimates of disappearance half-times for strontium-90 and cesium-137 based on 1962 weekly data from the Pasteurized Milk Network[1] (Averages for the U.S. were based on 4 sets of criteria used to identify an acute contaminating event during the pasture season at each of the milk stations in the 48 conterminous States.)

Criteria	Disappearance half-times (average in days)[2]	Number of curves identified
Set 1		
Strontium-89	13	16
Strontium-90	15	16
Cesium-137	15	16
Set 2		
Strontium-89	11	39
Set 3		
Strontium-90	11	50
Set 4		
Cesium-137	10	25

[1] Disappearance half-times of selected radionuclides in milk based on Surveillance Data, Gaynell Jayson and Anne G. Berger, DHEW, Public Health Service, Division of Radiological Health (report in preparation).

[2] An effective half-life or a disappearance half-time was determined for a given episode following the date of the maximum observed concentration.

Criteria

Set 1

A. Concomitant increases in ^{89}Sr, ^{90}Sr and ^{137}Cs

B. A 100 percent or greater increase in one or more of the nuclides in a one or two-week period

C. Maximum or peak concentrations of all three nuclides within a two-week period

D. Cows on pasture for the period

Set 2

A. 200 percent or greater increase in ^{89}Sr in a one or two-week period

B. Cows on pasture for the period

Set 3

A. 100 percent increase or greater in ^{90}Sr in a one or two-week period

B. Cows on pasture for the period

Set 4

A. 200 percent or greater increase in ^{137}Cs in a one or two-week period

B. Cows on pasture for the period

Appendix 3. The relative magnitude of milk and non-milk contributions to strontium-90 and cesium-137 body burdens

F. P. Hungate

In the United States the general population dietary pattern is such that milk is the major route by which strontium-90 is taken into man. From dietary studies of New York, Chicago, and San Francisco (as reported in HASL-144) the average ratio of strontium-units (pCi ^{90}Sr/gCa) from total diet to those from milk ranged from 1 to 2.5. In terms of strontium-90 in total diet to that in milk, this ratio varies from 1.5 in New York to 3 in San Francisco. For cesium-137 the ratios of total diet to milk ranges from about 2 in New York to nearly 8 in San Francisco. The HASL report tentatively concludes that, while milk appears to define the average strontium-90 intake, other products such as meat and cereals may assume equal or greater importance than milk with respect to body burdens of cesium-137.

These Tri-City diet data are from large groups of people and, as such, it is surprising that they show the variation they do. Individual dietary patterns involving the intake of large amounts of other foods containing higher than average concentrations of fallout radionuclides would inevitably lead to strontium-90 intakes which are primarily dependent on non-dairy products. In the case of strontium-90 this individual variation is largely outweighed by the importance of milk in the diet of infants and children. This same importance does not appear to hold for cesium-137.

Since action levels will undoubtedly have to be applied with respect to small and local segments of the general population, exceptional rather than average dietary patterns should be considered for their potential buildup of non-

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average body burdens. To date, relatively few of such unusual dietary patterns have been shown to produce unusual body burdens of radionuclides. This failure to identify any unusual patterns is undoubtedly the consequence of a lack of extensive studies of individual diets under conditions where body burdens can be evaluated through whole-body counting.

The study of cesium–137 body burdens in Alaskan Eskimos and Laplanders and associated evaluation of dietary patterns has been done on an individual basis. In these groups, cesium–137 body burdens are nearly 100 times those of individuals from the conterminous States having a "normal" intake of cesium–137 via milk. This high body burden in Eskimos occurs in spite of the fact that fallout levels in Alaska are well below those in areas less far north. With the exception of small children, the Eskimos consume essentially no milk or milk products but instead take in the vast majority of their cesium–137 by way of caribou meat.

Similar kinds of deviations from "normal" nutritional patterns may occur through food chains little suspected as of the present time. One such has been recently identified in Finnish studies in which fish were shown to contain up to 20 pCi $^{137}Cs/g$. Since fish are a major item in some people's diet, significantly higher than average body burdens can be expected.

Any concept of radionuclide burdens as derived through milk are automatically not valid for substantial parts of the world in which milk consumption is near zero for any except infants.

Appendix 4. Intake of radiocesium from contaminated meat

F. W. Lengemann

Milk and meat can constitute important pathways for the dissemination of radiocesium to the human population. The basic equations for secretion of cesium–137 into milk have been presented along with the equations for strontium–89 and strontium–90 levels in milk (Appendix 1). This section will present the same type of analysis for meat as a source of radiocesium for humans.

As in the previous section on milk the basic assumption was a single contaminating event that takes place in a short interval of time. It is assumed that cattle were grazing the pastures at the time of the event. Unlike milk, it must be further assumed that animals are taken directly from pasture and processed into meat and meat products. The number of animals must necessarily be large and the food distribution channels of sufficient magnitude so that a single animal contributes at most only one portion of the daily meat intake of an individual human. Such things as freezer storage of large amounts of meat from a single animal for a single family necessarily invalidate the analysis developed here.

The data presented here are body contents of cesium from 4 of the 7 cows used for the milk analysis (Appendix 1) and were given radiocesium daily for a period of 30 days. While the cows were milking animals, it is not anticipated that the general shape of the curve should be much different for beef animals since only about 10 percent of the daily intake of radiocesium is secreted into the milk.

The basic equation for meat radiocesium content from these experiments is:

$$(1)\quad \text{percent of daily cesium intake/kg meat} = 0.84e^{0.0073t}(1-e^{-0.2t})$$

For uniformity it is again assumed that the loss of cesium–137 from pasture grass is in the order of 14 days. The equation then modifies to:

$$(2)\quad \text{percent of daily cesium intake/kg meat} = 0.84e^{0.0073t}(1-e^{-0.2t})(e^{-0.05t})$$

The problem also entailed estimating what would happen to meat cesium–137 if the animals were removed from pasture. No data is available on this point; therefore the equation for the radiocesium content of milk after a single dose was used. The equation is:

$$(3)\quad \text{percent } {}^{137}\text{Cs/kg} = 0.23e^{-0.37t} + 0.08e^{-0.17t} + 0.01e^{-0.02t}$$

The use of this equation seemed reasonable since the cesium does not form organic combinations.

The equation (1) shows that when cattle are on a contaminated pasture the muscle concentration of cesium should peak at about 8 days. Integrating this equation from zero to infinity and dividing this value by the maximum concentration in meat (day 8) shows that the human intake of cesium–137 will be 34 times the maximum observed cesium concentration in meat. For this computation to hold, the animals must remain on pasture until slaughtered; the human must consume the flesh of a different animal each day, and must consume 1 kg of meat per day. If the meat consumption is only 0.5 kg then the total intake will be 17 times the maximum concentration. About 17 percent of the projected intake will take place in the first 8 days.

If the animals are maintained on pasture, the cesium–137 in the meat will decline due to pasture losses of the radioisotope. It is calculated that at day 68 the meat cesium–137 will be at a level 1æ10 that seen on day 8. On day 122 the cesium–137 will be 1/100 that of day 8.

These factors are in excellent agreement with those for milk (Appendix 1) and support the use of milk concentration curves for an index of muscle cesium levels. If at day 8, the time of maximum tissue cesium concentration, the animals are shifted to an uncontaminated feed, it can be calculated that it would take 8 and 49 days for the meat cesium–137 concentration to drop by a factor of 10 and 100, respectively. For individuals consuming meat from these animals it is calculated that their projected intake of cesium–137 will be 32 percent of that if the animals are not transferred from the contaminated pastures.

As for milk, a reduction of the projected intake by 50 percent can be accomplished by changing the animals to uncontaminated feed at about 20 days. A change at about 7 days will effect a 75 percent reduction; a change at 2 days, a 90 percent reduction; and at day 1, a 95 percent reduction.

It is customary to move dairy cattle directly from pasture to the slaughter house and so this analysis has relevance to the practical situation. The 24 million dairy cattle in this country constitute about half of the meat supply of this country. Most of these animals are processed into meat products such as chopped meat and bologna. For beef cattle the usual practice is to fatten the animals for several months on high grain diets before slaughter. Thus, these animals could be expected to be low in cesium–137 even in areas where a contaminating event has taken place.

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Section III—Water

GROSS RADIOACTIVITY AND STRONTIUM-90 IN SURFACE WATERS OF THE UNITED STATES, JANUARY 1965

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to 131 stations as of June 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining current and general levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–6*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term radioactivity effects from current or recent nuclear tests or events.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for

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counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents January 1965 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed begin closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the January 1965 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for 1957–1962 have been summarized by Weaver *et al* (*8*).

Strontium–90 determinations and results, October-December 1964

Beginning in 1959, strontium–90 analyses of the total solids of surface waters were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where quarterly analyses were continued. The method used for

Table 1. Radioactivity in raw surface waters, January 1965 [a]

Station	Beta activity, pCi/liter			Alpha activity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	6	14	20	2	2	4
Arkansas River:						
Coolidge, Kans	8	93	101	1	38	39
Ponca City, Okla	0	17	17	0	4	4
Atchafalaya River:						
Morgan City, La[b]	268	10	278	60	2	62
Bear River:						
Preston, Idaho	0	12	12	0	3	3
Big Horn River:						
Hardin, Mont	7	26	33	2	10	12
Clinch River:						
Clinton, Tenn	1	7	8	0	0	0
Kingston, Tenn	8	36	44	<1	0	<1
Colorado River:						
Loma, Colo	1	16	17	1	9	10
Page, Ariz	3	31	34	0	10	10
Parker Dam, Calif-Ariz	1	28	29	0	10	10
Columbia River:						
Wenatchee, Wash	3	7	10	0	1	1
Pasco, Wash	21	403	424	0	1	1
Clatskanie, Ore	15	23	38	2	2	4
Connecticut River:						
Enfield Dam, Conn	20	9	29	0	1	1
Coosa River:						
Rome, Ga	5	6	11	1	0	1
Cumberland River:						
Cheatham Lock, Tenn	8	6	14	2	0	2
Delaware River:						
Philadelphia, Pa	29	6	35	6	0	6
Great Lakes:						
Duluth, Minn	6	12	18	0	0	0
Hudson River:						
Poughkeepsie, N.Y	8	14	22	1	0	1
Kansas River:						
De Soto, Kans	14	17	31	6	4	10
Maumee River:						
Toledo, Ohio	4	20	24	1	1	2
Mississippi River:						
St. Paul, Minn	1	20	21	0	1	1
E. St. Louis, Ill	15	19	34	5	1	6
New Orleans, La	36	12	48	3	1	4
New Roads, La	17	12	29	5	1	6
Missouri River:						
Williston, N. Dak	29	26	55	7	6	13
St. Joseph, Mo	6	25	31	1	3	4
North Platte River:						
Henry, Nebr	3	47	50	0	30	30
Ohio River:						
Cairo, Ill	25	5	30	4	0	4
Toronto, Ohio	4	11	15	0	0	0
Platte River:						
Plattsmouth, Nebr	5	21	26	2	6	8
Potomac River:						
Washington, D.C	18	5	23	3	0	3
Red River, North:						
Grand Forks, N. Dak	2	28	30	0	0	0
Red River, South:						
Alexandria, La	18	21	39	3	2	5
Rio Grande:						
El Paso, Tex	8	34	42	2	9	11
Laredo, Tex	14	38	52	1	4	5
San Joaquin River:						
Vernalis, Calif	3	0	3	1	1	2
San Juan River:						
Shiprock, N. Mex	41	12	53	16	3	19
Savannah River:						
Port Wentworth, Ga	2	9	11	0	1	1
Snake River:						
Wawawai, Wash	5	9	14	1	2	3
South Platte River:						
Julesburg, Colo	14	61	75	3	37	40
Tennessee River:						
Chattanooga, Tenn	4	10	14	0	1	1
Wabash River:						
New Harmony, Ind	6	10	16	1	1	2
Yellowstone River:						
Sidney, Mont	2	20	22	0	5	5
Maximum	268	403	424	60	38	62
Minimum	0	0	3	0	0	0

[a] These data are preliminary: reanalysis of some samples may be made and additional analysis not completed at the time this report becomes available. For final data, one should consult the system's annual report.

[b] The increased radioactivity observed at this station is being investigated further and will be discussed in a forthcoming issue of Radiological Health Data.

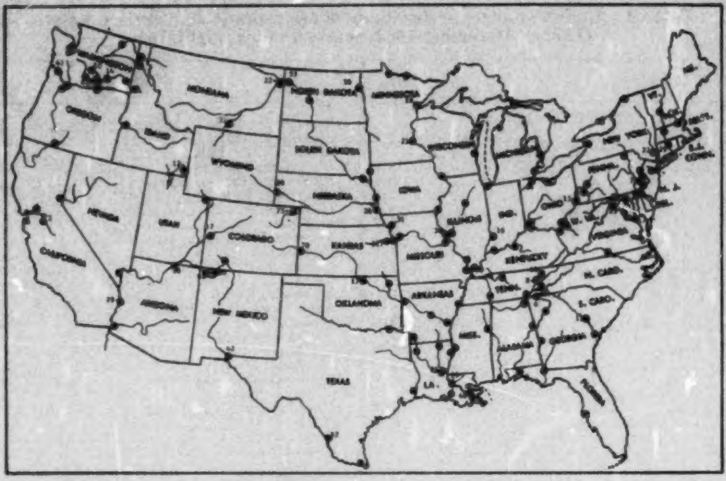

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, January 1965

determining strontium–90 is a modification of a procedure described by Harley (*9*). The yttrium–90 together with an yttrium carrier is precipitated as yttrium oxalate and the latter is washed, dried, weighed, and counted in a low-background, anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium–90 concentrations in U.S. surface waters for October-December 1964. The stations are arranged in the table according to their relative locations on the river, the first station being closest to the headwaters. Floyd and Weaver summarized the strontium–90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*10*).

An improvement has been made in the determination of the counting efficiency of the low-background anticoincidence end-window counter for the counting of yttrium–90 in the strontium–90 determination. Previously, an efficiency of approximately 33 percent had been determined on each of the two counting chambers with the use of a standard consisting of strontium–90-yttrium–90 in equilibrium. Before counting the present set of samples, the efficiencies obtained were 40.2 percent and 38.3 percent in the two counting chambers, respectively, with the use of pure yttrium–90 oxalate. The effect of these recent values is to lower strontium–90 values about 15 percent. Present data are calculated with the use of these more applicable efficiency values.

Sixty-eight quarterly composite samples were analyzed for strontium–90. The average concentration of strontium–90 is 1.80 pCi/liter.[1] The median concentration of strontium–90 is 1.69 pCi/liter. Twenty-nine stations showed no appreciable change over the previous quarter from which results had been obtained. Thirty-five stations showed a decrease in strontium–90 levels. Only one station, Wenatchee, Washington on the Columbia River showed an increase to 2.2 pCi/liter. The highest strontium–90 result for this quarter is 5.4 pCi/liter at Grand Forks, North Dakota. This value is 1.6 pCi/liter less than the previous determination. While there are no standards for strontium–90 activity of total solids in surface waters, the Public Health Service Drinking Water Standards set the limit for strontium–90 concentrations in drinking water at 10 pCi/liter (*11*). This limit for public water supplies is greater than the highest level observed in surface waters during October-December 1964.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the

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[1] All comparisons of present strontium–90 data to previous data presented herein have been made after appropriate corrections for changes in determining counting efficiency.

Table 2. Quarterly average strontium-90 concentrations in surface waters, October–December 1964, concentrations in pCi/liter

Station	^{90}Sr
Allegheny River:	
Pittsburgh, Pa	1.7
Arkansas River:	
Ponca City, Okla	2.9
Little Rock, Ark	2.9
Pendleton Ferry, Ark	2.8
Big Horn River:	
Hardin, Mont	1.7
Chattahoochee River:	
Atlanta, Ga	1.6
Columbus, Ga	1.2
Chena River:	
Fairbanks, Alaska	0.1
Clinch River:	
Kingston, Tenn	3.0
Colorado River:	
Loma, Colo	0.9
Boulder City, Nev	1.7
Yuma, Ariz	1.2
Columbia River:	
Wenatchee, Wash	1.8
Pasco, Wash	2.2
McNary Dam, Ore	1.6
Clatskanie, Ore	1.0
Connecticut River:	
Northfield, Mass	1.3
Delaware River:	
Martins Creek, Pa	1.3
Philadelphia, Pa	1.2
Escambia River:	
Century, Fla	0.9
Great Lakes:	
Duluth, Minn	0.5
Milwaukee, Wis	0.8
Port Huron, Mich	1.2
Buffalo, N. Y	2.3
Hudson River:	
Poughkeepsie, N. Y	2.0
Illinois River:	
Peoria, Ill	1.6
Kansas River:	
DeSoto, Kans	3.3
Klamath River:	
Keno, Ore	1.5
Maumee River:	
Toledo, Ohio	2.1
Mississippi River:	
Dubuque, Iowa	2.9
East St. Louis, Ill	2.7
West Memphis, Ark	2.2
Delta, La	2.4
New Roads, La	2.1
Missouri River:	
Williston, N. Dak	2.1
Yankton, S. Dak	2.3
St. Joseph, Mo	3.0
Missouri City, Mo	3.6
Monongahela River:	
Pittsburgh, Pa	1.8
North Platte River:	
Henry, Nebr	0.5
Ohio River:	
Toronto, Ohio	2.0
Huntington, W. Va	1.4
Louisville, Ky	2.1
Cairo, Ill	2.1
Pend Oreille River:	
Albeni Falls Dam, Idaho	1.0
Potomac River:	
Williamsport, Md	0.8
Rainy River:	
Baudette, Minn	3.5
International Falls, Minn	3.2
Red River, North:	
Grand Forks, N. Dak	5.4
Red River, South:	
Index, Ark	3.4
Alexandria, La	2.7
Rio Grande:	
Alamosa, Colo	0.7
Laredo, Tex	1.7
Roanoke River:	
John H. Kerr Resr/Dam, Va	1.5
San Joaquin River:	
Vernalis, Calif	1.0
San Juan River:	
Shiprock, N. Mex	2.1
Savannah River:	
Port Wentworth, Ga	1.8
Shenandoah River:	
Berryville, Va	0.5
Snake River:	
Wawawai, Wash	0.6
Payette, Idaho	0.6
South Platte River:	
Julesburg, Colo	0.7
Tennessee River:	
Lenoir City, Tenn	1.2
Chattanooga, Tenn	1.3
Bridgeport, Ala	1.0
Truckee River:	
Farad, Calif	0.6
Verdigris River:	
Nowata, Okla	3.0
Wabash River:	
New Harmony, Ind	1.6
Willamette River:	
Portland, Ore	0.3

absence of strontium-90 and alpha emitters,[2] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*11*).

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(*3*) *Ibid.*, 1960 Edition.[3]

(*4*) *Ibid.*, 1961 Edition.[3]

(*5*) *Ibid.*, 1962 Edition.[3]

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(*7*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition, New York (1960).

(*8*) WEAVER, L., A. W. HOADLEY, and S. BAKER. Radioactivity in surface waters of the United States, 1957–1962. Rad Health Data 4: 306–16 (June 1963).

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(*11*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

(*12*) STRAUB, C. P. Significance of radioactivity data. JAWWA 53:704 (June 1961).

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[2] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

[3] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

Section IV—Other Data

STRONTIUM-90 IN HUMAN BONE, OCTOBER 1964-MARCH 1965

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for only about ten years and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post-mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally this amount is readily available from older children but it presents some difficulties from the standpoint of infants and children under five years of age.

Collection efforts are concentrated in five areas representing a broad range of environmental strontium–90 levels. These areas include metropolitan centers at Boston, Cincinnati, New Orleans, Los Angeles and Seattle.[1] Occasional specimens are also received from a few other areas.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison to British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. The yttrium fraction is separated from the bone ash by extraction with 2-thenoyltrifluoroacetone (TTA). The strontium–90 content is then calculated (*2, 3*) from the yttrium–90 activity. "Blind" duplicate analyses are performed on 10–20 percent of the samples. In addition, pools of animal bone ash and adult human bone ash are analyzed in replicate on a continuing basis.

Results

The results of laboratory analyses for October 1964 through March 1965 are presented in table 1. The samples are grouped by States within each of six geographical regions as shown in figure 1. These regions represent an attempt to combine some elements of climatic and topographic homogeneity with the pattern of strontium–90 levels as reflected by the Public Health Service Pasteurized Milk Network.

The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Following the pattern of earlier reports

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[1] The U.S. Atomic Energy Commission has an active program for the collection of bone samples in New York, Chicago, and San Francisco (*1*).

Table 1. Details of samples and results of analysis, October 1964–March 1965

Region, state, and sample	Age at death	Sex	Date of death	Bone [a]	Original weight (g)	Ash weight (g)	pCi ^{90}Sr/g of		
							Ash ±2σ C.E.	Calcium	Bone
Northeast									
Connecticut									
I-16(0008)	8 y 11 m 6 d	M	5-5-64	V	193.8	22.0	1.46±.11	3.99	.17
Massachusetts									
I-2(0063)	10 y 11 m 6 d	M	1-7-64	V	88.5	7.1	1.51±.09	4.12	.12
I-2(0064)	25 y 5 m 24 d	M	1-7-64	V	100.1	15.0	.87±.14	2.30	.13
I-2(0066)	4 y 7 m 19 d	M	1-10-64	V	131.4	12.5	1.54±.15	4.26	.15
I-2(0069)	13 y 7 m	M	1-22-64	V	208.5	20.9	1.08±.09	2.94	.11
I-2(0070)	11 y 10 m 3 d	M	1-23-64	V	191.0	17.7	.77±.08	2.10	.07
I-2(0071)	13 y 8 m 5 d	M	1-23-64	V	229.8	21.9	1.12±.08	2.98	.11
I-2(0072)	11 y 0 m 18 d	M	1-30-64	V	131.0	13.3	1.03±.12	2.85	.11
I-2(0073)	6 y 7 m 12 d	M	1-31-64	V	138.6	17.1	1.80±.13	4.83	.22
I-2(0077)	12 y 8 m 26 d	M	2-16-64	V	127.9	11.1	1.45±.16	4.29	.13
I-2(0078)	12 y 4 m 7 d	F	2-16-64	V	90.0	9.0	.92±.13	2.52	.09
I-2(0079)	23 y 0 m 23 d	F	2-21-64	V	151.0	20.8	1.46±.10	3.84	.20
I-2(0080)	11 y	F	3-1-64	V	146.7	15.4	1.40±.12	3.79	.15
I-2(0085)	8 y 9 m 2 d	M	3-11-64	V	105.4	8.9	2.45±.23	6.95	.21
I-2(0087)	8 y	M	3-16-64	V	115.2	10.0	1.59±.16	4.45	.14
I-2(0088)	8 y 4 m 21 d	M	3-20-64	V	111.7	11.0	1.81±.17	4.97	.18
I-2(0089)	12 y 8 m 15 d	M	3-21-64	V	96.8	6.5	1.75±.22	4.94	.12
I-2(0091)	9 y 9 m 20 d	F	3-25-64	V	195.6	19.4	1.48±.10	3.99	.15
I-2(0093)	6 y 6 m	M	4-3-64	V	128.3	11.8	1.39±.10	4.19	.13
I-2(0094)	15 y 5 m 7 d	F	4-5-64	V	241.0	24.9	1.06±.08	2.90	.11
I-2(0095)[b]	25 y 7 m	F	4-5-64	V	134.3	15.9	.60±.07	1.59	.07
I-2(0097)[b]	11 y 11 m 23 d	F	4-10-64	V	139.2	16.5	1.30±.10	3.41	.15
I-2(0097)[b]	11 y 11 m 23 d	F	4-10-64	V	139.2	16.5	1.11±.09	2.94	.13
I-2(0099)	4 y 4 m	F	4-21-64	V	105.8	9.3	2.09±.18	5.68	.18
I-2(0100)	6 y 9 m 29 d	M	4-28-64	V	89.0	8.3	1.49±.18	4.20	.14
I-2(0101)	15 y 11 m	F	5-2-64	V	103.9	12.7	1.89±.16	5.14	.23
I-2(0104)	4 y 7 m	M	5-10-64	V	120.3	9.9	1.80±.19	4.89	.15
I-2(0105)	7 y 5 m 3 d	F	5-14-64	V	121.2	9.3	2.27±.19	6.41	.17
I-2(0107)[c]	4 y 5 m	F	5-22-64	V	128.1	11.1	2.60±.18	7.28	.23
I-2(0107)[c]	4 y 5 m	F	5-22-64	V	128.1	11.1	2.90±.21	8.10	.25
I-2(0111)[b]	11 y 1 m	F	5-27-64	V	115.8	13.9	1.39±.12	3.60	.17
I-2(0111)[b]	11 y 1 m	F	5-27-64	V	115.8	13.9	.94±.11	2.51	.11
I-2(0119)	4 y 8 m 24 d	F	7-17-64	V	75.3	8.1	2.58±.23	7.04	.28
I-2(0141)	13 y	F	12-12-64	V	133.6	13.5	1.32±.12	3.57	.13
I-2(0142)	10 y	M	12-12-64	V	163.4	17.3	1.84±.12	5.17	.20
I-7(0005)[b]	17 y	M	11-30-64	V	103.35	17.1	1.55±.11	4.14	.26
I-7(0007)	10 y	F	12-17-64	V	100.1	9.2	1.85±.18	5.21	.17
I-8(0004)	16 y 5 m 16 d	F	1-5-65	V	143.5	16.9	1.23±.11	3.40	.14
I-8(0007)	24 y	F	2-2-64	V	109.6	12.7	1.10±.12	2.90	.13
I-8(0011)[b]	21 y 8 m 1 d	M	5-4-64	V	96.4	14.1	1.31±.18	3.54	.19
I-8(0011)[b]	21 y 8 m 1 d	M	5-4-64	V	96.4	14.1	1.29±.11	3.42	.19
I-8(0012)	22 y 17 d	F	5-11-64	V	73.7	10.2	1.47±.25	3.88	.20
I-8(0014)	17 y 5 m	M	5-11-64	V	78.8	9.2	1.98±.29	5.39	.23
I-8(0015)	20 y	M	5-12-64	V	97.1	12.2	1.19±.18	3.12	.15
I-8(0018)	6 y	M	5-28-64	V	110.0	10.9	1.39±.14	3.78	.14
I-8(0019)	10 y	F	5-26-64	V	70.8	8.0	1.58±.18	4.12	.18
I-8(0021)	17 y	F	7-14-64	V	46.0	5.6	1.49±.29	3.94	.18
I-8(0022)	6 y 10 m 25 d	F	8-7-64	V	88.7	8.1	1.91±.20	5.53	.17
I-8(0023)	20 y	M	8-30-64	V	127.1	16.3	1.48±.13	3.98	.19
I-8(0024)	2 y 6 m	F	10-1-64	V	47.3	4.7	2.96±.92	8.35	.29
I-8(0025)	22 y	M	10-17-64	V	97.8	14.1	1.27±.12	3.38	.18
New Jersey									
II-36(0004)	4 y 6 m 22 d	F	4-20-64	V, R	203.1	9.6	1.57±.15	4.49	.05
New York									
II-10(0010)[b]	14 y 1 m 26 d	M	6-13-63	V	176.5	8.6	.64±.13	1.84	.02
II-10(0018)	12 y 1 m 4 d	F	8-13-63	V	161.5	21.3	.99±.09	2.66	.13
II-10(0025)	11 y 2 m 15 d	M	3-11-64	V	197.2	18.1	1.10±.10	3.06	.10
II-12(0011)	15 y 1 m 19 d	F	5-15-63	V	144.9	16.3	.72±.08	1.91	.08
II-12(0012)	13 y 7 m 8 d	M	5-7-63	V	174.2	16.3	.84±.10	2.33	.08
II-12(0014)	24 y 4 m 25 d	M	7-22-63	V	105.0	12.8	1.51±.13	3.98	.18
II-23(0001)	21 y 4 m 5 d	M	3-27-64	V	157.1	24.8	0.71±.07	1.85	.11
II-23(0004)[b]	23 y 29 d	M	6-23-64	V	135.2	16.7	.89±.09	2.43	.12
II-23(0004)[b]	23 y 29 d	M	6-23-64	V	135.2	16.7	.82±.08	2.10	.10
II-26(0002)[b]	16 y 9 m 12 d	M	6-6-63	R	48.3	15.9	.99±.09	2.45	.33
II-26(0002)[b]	16 y 9 m 12 d	M	6-6-63	R	96.6	15.9	.74±.09	1.85	.12
II-26(0003)	16 y 14 d	M	4-1-64	R	111.7	27.2	1.01±.07	2.58	.27
II-38(0010)	9 y 1 m 13 d	M	3-11-64	V	143.7	12.8	1.59±.15	4.38	.14
II-38(0011)	11 y 2 m 23 d	M	3-27-64	V	203.7	19.3	1.08±.09	3.00	.10
II-38(0012)	24 y 11 m 4 d	F	3-28-64	V	146.9	15.8	.94±.10	2.52	.10
II-38(0021)[b]	20 y 2 m 16 d	F	5-18-64	V	116.6	18.3	.53±.06	1.54	.08
II-38(0023)	22 y 9 m 5 d	M	5-19-64	V	239.5	23.3	.65±.06	1.69	.06
Pennsylvania									
II-3(0006)	23 y 2 m 15 d	M	8-23-63	V	152.2	20.9	.83±.09	2.17	.11
II-3(0007)	19 y 4 m 22 d	F	11-25-63	V	195.5	29.8	.91±.06	2.43	.14
II-3(0009)	13 y 3 m 29 d	M	4-18-64	V	161.7	15.3	1.49±.13	4.16	.14
II-4(0022)	24 y 1 d	F	2-25-64	V	226.8	22.1	1.22±.09	3.23	.06
II-19(0035)	19 y 9 m	M	5-20-63	V	143.4	21.0	.65±.07	1.67	.10
II-19(0036)	22 y 1 m 15 d	M	5-17-63	V	167.3	24.3	.57±.06	1.51	.09

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Table 1. Details of samples and results of analysis, October 1964–March 1965—Continued

Region, state, and sample	Age at death	Sex	Date of death	Bone [a]	Original weight (g)	Ash weight (g)	pCi ^{90}Sr/g of Ash ±2σ C.E.	Calcium	Bone
Northeast—Continued									
Pennsylvania									
II-19(0037)	15 y 2 m 11 d	M	6-17-63	V	195.7	22.0	.94±.08	2.50	.11
II-19(0051)	8 y 8 m 6 d	M	10-21-63	V	90.0	9.8	1.51±.19	4.14	.16
II-19(0055)	23 y 11 m 24 d	F	11-6-63	V	182.7	21.7	.88±.08	2.38	.11
II-19(0057)[b]	21 y	F	11-30-63	V	111.3	18.4	.85±.09	2.23	.07
II-19(0057)[b]	21 y	F	11-30-63	V	111.3	18.4	.78±.08	2.03	.13
II-19(0062)	6 y 7 m 21 d	F	4-1-64	V	154.5	17.3	1.33±.11	3.64	.15
Vermont									
I-6(0033)	19 y 9 m 20 d	M	1-9-64	V	174.3	21.1	1.33±.09	3.55	.16
I-6(0035)[b]	23 y 8 m 5 d	M	2-8-64	V	139.4	17.1	1.15±.09	3.09	.14
I-6(0035)[b]	23 y 8 m 5 d	M	2-8-64	V	139.4	17.1	1.35±.11	3.63	.17
I-6(0037)	15 y 8 m 9 d	M	4-3-64	V	169.8	23.9	1.59±.09	4.31	.23
I-6(0038)	15 y 1 m 2 d	M	4-3-64	V	186.8	22.9	1.44±.09	3.90	.18
I-6(0039)	14 y 21 d	M	4-28-64	V	182.1	22.6	1.97±.11	5.36	.25
I-6(0041)[b]	17 y 3 m 12 d	M	4-28-64	V	139.9	20.0	1.16±.08	3.08	.17
I-6(0041)[b]	17 y 3 m 12 d	M	4-28-64	V	139.9	20.0	1.13±.09	3.00	.16
I-6(0044)[b]	15 y 2 m 4 d	M	6-26-64	V	106.7	14.8	1.72±.13	4.62	.24
I-6(0044)[b]	15 y 2 m 4 d	M	6-26-64	V	106.7	14.8	1.37±.11	3.77	.19
I-6(0046)[b]	14 y 10 m 17 d	M	7-17-64	V	115.6	16.0	2.15±.15	5.69	.30
I-6(0046)[b]	14 y 10 m 17 d	M	7-17-64	V	115.6	16.0	1.99±.13	5.21	.28
I-6(0048)	15 y	M	10-12-64	V	221.3	27.1	1.56±.09	4.22	.19
I-6(0049)	12 y 8 m	M	10-11-64	V	199.0	20.0	1.71±.12	4.83	.17
I-6(0051)	21 y 1 m 25 d	M	11-26-64	V	224.8	27.4	1.39±.08	3.69	.17
Southeast									
Maryland									
III-7(0035)	7 y 4 m 11 d	M	5-15-63	V	117.3	11.7	.92±.12	2.54	.09
III-7(0041)	16 y 1 m 27 d	M	8-1-63	V	147.2	23.8	.77±.07	2.00	.12
III-7(0042)	15 y 1 m 3 d	M	8-12-63	V	166.5	23.2	1.08±.08	2.74	.15
III-7(0044)[b]	24 y 8 m 14 d	M	8-17-63	V	108.1	19.2	.88±.08	2.27	.16
III-7(0044)[b]	24 y 8 m 14 d	M	8-17-63	V	108.1	19.2	.79±.07	2.03	.14
III-7(0045)	15 y 4 m 17 d	M	8-18-63	V	198.9	24.2	1.17±.09	3.10	.14
III-7(0046)[a]	17 y 1 m 27 d	M	8-17-63	V	109.7	13.7	.90±.10	2.41	.11
III-7(0046)[a]	17 y 1 m 27 d	M	8-17-63	V	109.7	13.7	.90±.10	2.40	.11
III-7(0047)	21 y 21 d	M	8-18-63	V	142.9	19.7	.84±.08	2.19	.12
III-7(0048)	22 y 6 m 17 d	M	8-30-63	V	157.0	24.0	.44±.05	1.15	.07
III-7(0051)	18 y 9 m 8 d	M	10-27-63	V	208.0	24.9	.97±.07	2.56	.12
III-7(0052)	20 y 21 d	M	10-27-63	V	155.9	24.1	.57±.06	1.49	.09
III-7(0053)[b]	22 y 4 m 29 d	M	11-8-63	V	89.8	14.3	.84±.10	2.17	.13
III-7(0053)[b]	22 y 4 m 29 d	M	11-8-63	V	89.8	14.3	.91±.12	2.36	.15
III-7(0054)	21 y	M	11-8-63	V	87.1	13.0	1.08±.12	2.88	.08
III-7(0055)	22 y 3 m 16 d	M	12-8-63	V	185.3	21.9	.87±.08	2.32	.10
III-7(0057)[b]	22 y 8 m 21 d	F	9-7-63	V	97.7	13.8	.65±.08	1.72	.09
III-7(0058)	22 y 5 m 15 d	M	9-2-63	V	157.3	21.3	.55±.07	1.43	.07
Eastern Tennessee									
IV-14(0008)	12 y 2 m 2 d	M	2-7-64	V	188.0	19.8	1.82±.12	4.94	.19
Virginia									
III-5(0004)[b]	21 y 11 d	M	6-23-63	V, R	122.6	19.1	.42±.06	1.10	.03
III-5(0005)	5 y 10 m 9 d	F	7-21-63	V	103.0	9.9	1.34±.15	3.50	.12
Central									
Minnesota									
VI-1(0012)	8 y 5 m 2 d	F	2-15-64	V, St	209.8	12.5	12.8±.12	4.17	.08
VI-1(0013)[b]	15 y 11 m	F	5-14-64	V	140.8	18.7	.96±.09	2.57	.06
VI-1(0013)[b]	5 y 11 m	F	5-14-64	V	140.8	18.7	1.03±.09	2.69	.14
VI-19(0013)[b]	22 y 7 m 29 d	F	5-7-64	V	117.1	15.6	.90±.09	2.46	.12
VI-19(0013)[b]	22 y 7 m 29 d	F	5-7-64	V	117.1	15.6	.90±.10	2.14	.12
VI-19(0016)	21 y 5 m 10 d	F	6-1-64	V	214.5	26.7	1.31±.08	3.44	.16
VI-19(0019)[b]	18 y 2 m 9 d	M	8-18-64	V	121.4	19.5	.94±.08	2.41	.15
VI-19(0021)[b]	17 y 5 m 17 d	M	9-10-64	V	135.3	14.9	1.19±.12	3.19	.13
VI-19(0021)[b]	17 y 5 m 17 d	M	9-10-64	V	135.3	14.9	1.72±.16	4.69	.19
Missouri									
VI-4(0001)	16 y 10 m 4 d	M	7-24-63	V	175.0	22.3	1.36±.09	3.54	.17
VI-4(0002)[b]	18 y 6 m	M	8-17-63	V	117.3	17.2	1.08±.11	2.87	.16
VI-7(0019)	17 y	F	3-7-64	V	275.7	8.3	.93±.13	3.41	.03
Ohio									
V-1(0007)	5 y 5 m 27 d	M	6-27-63	V	146.6	10.1	1.46±.15	4.23	.10
V-1(0010)	6 y 2 m 6 d	F	10-2-63	V	151.3	16.0	.94±.10	2.56	.10
V-19(0085)	6 y 9 d	M	1-10-63	V	116.6	11.0	.83±.12	2.25	.08
V-19(0140)	5 y 11 m 29 d	F	10-30-63	V	138.3	10.9	1.79±.17	5.28	.14
V-19(0144)	3 y 7 m 12 d	F	9-11-63	V	118.0	9.1	2.02±.21	5.56	.16
V-19(0145)	4 y 10 m 8 d	F	10-26-63	V	132.7	10.0	1.81±.17	4.87	.14
V-19(0148)	7 y	M	10-2-63	V	106.3	9.6	0.83±.11	2.17	.08
V-19(0153)	9 y 6 m 20 d	F	3-21-64	V	139.4	13.6	.96±.11	2.50	.09
V-19(0157)	7 y 6 m 4 d	F	4-19-64	V	218.3	15.6	1.21±.13	3.30	.09
V-19(0158)	3 y 11 m 10 d	M	4-20-64	V, R	139.0	13.3	2.26±.15	5.79	.17
V-19(0196)	12 y 2 m 29 d	M	9-13-64	V	285.2	27.9	1.08±.07	2.93	.1[illegible]
V-19(0199)	12 y 9 m 13 d	M	9-26-64	V	110.8	12.5	1.50±.15	4.02	.17
V-19(0205)	3 y 1 m 21 d	M	11-3-64	V	81.3	3.8	2.97±.13	8.37	.14
V-25(0001)[b]	23 y 6 m 15 d	M	7-29-64	V	81.5	13.8	.70±.08	1.77	.12
V-25(0002)[b]	17 y 25 d	M	8-19-64	V, R	83.8	13.5	.95±.10	2.47	.15

Table 1. Details of samples and results of analysis, October 1964–March 1965—Continued

Region, state, and sample	Age at death	Sex	Date of death	Bone[a]	Original wt. (g)	Ash wt. (g)	pCi ^{90}Sr/g of		
							Ash ±2σ C.E.	Calcium	Bone
Central—Continued									
Wisconsin									
V-3(0032)	5 y 5 m 12 d	F	5-9-63	V	121.7	12.1	1.18±.17	3.34	.12
V-3(0063)	3 y 2 d	F	10-23-63	V	147.0	13.3	1.65±.16	4.77	.15
V-3(0133)	5 y 1 m 26 d	M	5-25-64	V	141.1	12.4	1.35±.14	3.70	.12
V-3(0138)	7 y 8 m 9 d	F	6-12-64	V	203.7	23.6	1.10±.08	2.99	.13
V-3(0175)	6 y 11 m 5 d	M	11-25-64	V	99.8	7.9	1.29±.17	3.52	.10
V-3(0177)	3 y 1 m 29 d	M	12-14-64	V	93.4	10.4	2.08±.17	5.70	.23
V-3(0178)	4 y 7 m 16 d	F	12-16-64	V	89.1	9.0	1.68±.18	4.49	.17
V-3(0180)	3 y 7 m 7 d	M	12-17-64	V	88.6	6.7	3.46±.28	9.78	.26
Delta									
Louisiana									
VII-6(0003)	19 y	M	9-9-64	V	120.5	21.8	1.97±.11	5.05	.36
VII-6(0004)	17 y 1 m 20 d	M	9-8-64	V	80.7	12.7	1.15±.11	3.06	.18
VII-8(0021)	7 y 29 d	F	2-12-64	V	137.5	12.7	1.91±.19	5.33	.18
VII-8(0022)	6 y 8 m 11 d	M	2-4-64	V	141.0	13.8	1.82±.14	5.37	.18
VII-8(0023)	6 y 2 m	F	2-21-64	V, R	109.2	10.7	.40±.05	2.85	.04
VII-8(0025)[b]	18 y 10 m 20 d	M	5-1-64	V	94.4	13.4	1.60±.12	4.27	.23
VII-8(0025)[b]	18 y 10 m 20 d	M	5-1-64	V	94.4	13.4	1.09±.11	2.83	.16
VII-8(0026)	3 y 3 m 23 d	F	5-2-64	V	136.1	14.2	2.46±.17	6.60	.26
VII-8(0027)	2 y 29 d	M	5-2-64	R	94.8	10.6	2.13±.19	5.74	.24
VII-8(0028)[b]	20 y 10 m 12 d	F	5-8-64	V, R	109.3	15.7	1.59±.12	4.27	.23
VII-8(0028)[b]	20 y 10 m 12 d	F	5-8-64	V, R	109.3	15.7	1.55±.13	4.02	.22
VII-8(0029)[b]	19 y 3 m 19 d	F	5-10-64	V	102.9	14.1	1.33±.13	3.55	.18
VII-8(0029)[b]	19 y 3 m 19 d	F	5-10-64	V, R	102.9	14.1	1.64±.13	4.40	.23
VII-8(0031)[b]	6 y 4 m 19 d	F	5-26-64	V	104.3	10.4	1.12±.12	3.13	.11
VII-8(0032)	4 y 6 m 1 d	M	6-7-64	V	130.9	13.3	1.35±.12	3.68	.14
VII-8(0033)[b]	17 y 1 m 11 d	F	6-9-64	V	103.8	17.7	1.40±.11	3.61	.24
VII-8(0033)[b]	17 y 1 m 11 d	F	6-9-64	V	103.8	17.7	1.17±.10	3.09	.20
VII-8(0034)[b]	16 y 5 m 15 d	M	9-27-64	V, R	115.2	14.8	1.54±.12	4.37	.21
VII-8(0035)[b]	24 y 7 m 21 d	F	9-27-64	V, R	94.2	16.2	.91±.10	2.43	.16
VII-8(0035)[b]	24 y 7 m 21 d	F	9-27-64	V, R	94.2	16.2	.72±.09	1.88	.12
Western Tennessee									
IV-9(0016)	17 y	M	1-10-64	V	135.3	21.6	0.77±.07	2.02	.12
IV-9(0017)	11 y	M	3-9-64	V	97.8	11.8	1.07±.12	2.88	.13
IV-9(0019)	19 y 2 m	M	3-14-64	V	76.9	10.7	1.34±.14	3.54	.19
IV-9(0020)	14 y 1 m 21 d	M	3-28-64	V	135.3	16.7	1.08±.11	2.89	.13
IV-9(0021)	16 y 11 m 5 d	F	4-7-64	V	86.7	13.9	1.11±.10	2.91	.18
Southwest									
Arizona									
IX-27([illegible]002)	5 y 7 m 25 d	F	3-29-64	V	123.9	10.4	.93±.14	2.50	.08
California									
IX-8(0023)	6 y 13 d	M	2-17-64	V	117.4	11.3	.76±.11	2.11	.07
IX-8(0024)	1 y 21 d	M	3-11-64	V	65.0	5.1	1.14±.10	3.21	.09
IX-8(0026)	3 y 6 d	F	9-21-64	V, R, St	168.2	14.6	.95±.10	2.68	.08
IX-8(0027)	2 d	F	10-8-64	V, R, LB	173.0	14.2	.47±.08	1.29	.04
IX-8(0028)	1 d	F	10-16-64	V, R, LB	224.0	25.8	.39±.05	1.04	.05
IX-8(0029)[b]	1 d	F	10-26-64	V, R, St, LB	195.5	19.6	.71±.08	2.06	.07
IX-8(0029)[b]	1 d	F	10-26-64	V, R, St, LB	195.5	19.6	.64±.06	1.75	.06
IX-8(0030)	1 m 20 d	M	11-18-64	V, LB	195.5	19.3	.56±.06	1.51	.06
IX-9(0011)[b]	23 y 1 m 5 d	M	3-13-63	V	156.3	19.8	0.35±.06	0.95	.05
IX-9(0011)[b]	23 y 1 m 5 d	M	3-13-63	V	156.3	19.8	0.24±.05	0.64	.03
IX-15(0004)	6 y 21 d	M	4-14-64	V	135.7	10.6	1.19±.14	3.37	.09
IX-15(0005)	1 y 9 d	M	5-2-64	V	61.3	8.5	1.01±.15	2.68	.14
IX-15(0007)	17 y	F	11-30-64	V	303.1	44.2	.65±.04	1.90	.10
IX-15(0008)	3 y 2 m	F	11-30-64	V	44.3	6.3	1.82±.23	5.18	.26
IX-21(0001)	14 y 3 m 9 d	M	12-20-63	V	158.3	20.5	0.68±.08	1.87	.09
IX-25(0001)	22 y 4 m 21 d	M	2-12-64	V, I	158.5	26.3	1.14±.08	2.98	.19
IX-25(0005)	13 y 3 m 9 d	M	5-5-64	V	149.6	17.2	.64±.07	1.74	.07
IX-25(0007)	1 y 10 m 19 d	M	5-25-64	V, I	129.5	12.2	1.47±.12	4.03	.14
IX-25(0008)	1 y 10 m 20 d	M	6-8-64	V, I	128.6	9.7	1.26±.14	3.64	.10
IX-25(0010)	5 y 6 m 10 d	M	6-23-64	V	132.5	9.7	.83±.12	2.44	.06
IX-25(0011)	5 y 4 m 20 d	F	6-24-64	V	172.0	15.4	0.89±.10	2.38	.08
IX-25(0012)	17 y 8 m 21 d	M	7-12-64	V	192.6	25.5	0.72±.06	1.95	.10
IX-25(0013)[b]	21 y 11 m 21 d	F	8-25-64	V	116.5	15.0	0.80±.09	2.19	.10
IX-25(0013)[b]	21 y 11 m 21 d	F	8-25-64	V	116.5	15.0	.68±.08	1.82	.09
IX-25(0014)	3 y 7 m 1 d	M	9-13-64	V	140.7	11.9	1.61±.15	4.16	.13
IX-25(0015)	22 y 29 d	F	9-28-64	V	143.9	19.0	1.06±.08	2.91	.14
IX-25(0016)	12 y 8 m 14 d	M	9-19-64	V	118.5	12.5	1.23±.13	3.37	.13
IX-32(0001)	22 y 7 m 23 d	F	2-15-64	V	93.6	10.4	.71±.11	1.87	.08

Table 1. Details of samples and results of analysis, October 1964–March 1965—Continued

Region, state, and sample	Age at death	Sex	Date of death	Bone [a]	Original wt. (g)	Ash wt. (g)	pCi Sr^{90}/g of		
							Ash ±2σ C.E.	Calcium	Bone
Northwest									
Alaska									
IX-34(0001)	22 y 9 m 28 d	F	[d]10-20-64	R	15.2	4.6	1.47±.05	3.91	.45
IX-34(0006)	20 y	M	[d]9-30-64	R	16.1	5.8	0.98±.05	2.02	.35
IX-13(0001)[b]	16 y 6 m 14 d	M	5-20-63	V	114.4	16.5	0.86±.09	2.50	.12
IX-13(0004)	18 y 8 m	M	8-21-63	V	213.8	25.9	0.16±.06	1.64	.07
IX-13(0006)[b]	16 y 5 m 11 d	M	1-17-64	V	100.8	14.2	2.32±.15	6.05	.33
IX-13(0006)[b]	16 y 5 m 11 d	M	1-17-64	V	100.8	14.2	3.06±.22	7.95	.43
IX-18(0001)	8 y 7 m	F	1-24-64	I	182.1	18.2	1.39±.11	4.31	.16
Washington									
IX-7(0018)	10 y 7 m 22 d	M	3-13-63	V	144.7	18.9	.60±.07	2.20	.08
IX-7(0026)	9 y 3 m 27 d	M	3-19-64	V	59.1	6.0	1.93±.22	5.16	.20
IX-7(0027)	16 y 10 m 10 d	F	6-10-64	V	96.8	16.9	1.06±.09	2.73	.19
IX-7(0028)	12 y 11 m 23 d	M	8-30-63	V	157.2	16.7	2.09±.15	5.61	.22
IX-13(0002)	17 y 3 m 25 d	M	6-13-63	V	180.2	21.3	.79±.07	2.09	.09
IX-13(0003)	17 y 10 m 24 d	M	6-13-63	V	160.7	20.5	.62±.06	1.62	.08
Other									
Colorado									
VIII-4(0001)	13 y 2 m 23 d	F	10-12-62	V	151.4	21.5	0.50±.06	1.30	.07
VIII-4(0003)[b]	10 y 11 m 14 d	M	6-24-64	V	101.8	20.4	0.76±.07	1.95	.15
VIII-4(0003)[b]	10 y 11 m 14 d	M	6-24-64	V	101.8	20.4	0.67±.07	1.72	.14
Texas									
VII-11(0002)[b]	13 y	M	[d]3-63	F	118.5	16.9	0.44±.07	1.11	.03
Utah									
VIII-1(0001)	6 y 28 d	M	12-5-62	V, R	115.6	12.1	0.75±.10	2.03	.08

[a] V, vertebra; R, rib; I, ilium; St, sternum; F, femur; LB, long bones.
[b] Blind duplicate—sample split and submitted on different dates for analysis.
[c] Duplicate analysis.
[d] Sample obtained by surgical procedure.

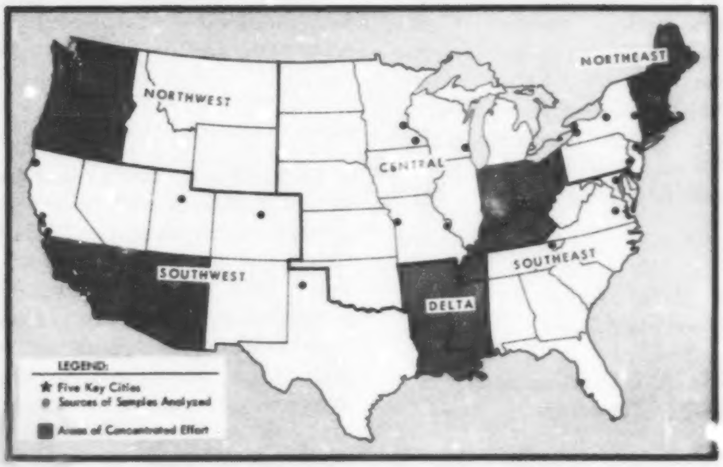

Figure 1. Regions for PHS bone sampling network and sources of samples analyzed, October 1964–March 1965

subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2*, *4*).

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Rad Health Data 5: 511–513 (October 1964).

(*2*) WEISS, E. W., W. H. LAND, K. H. FALTER, and R. M. Hallisey. Strontium-90 content of human bones (1961–1963). Rad Health Data 5:231–239 (May 1964).

(*3*) NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY, PUBLIC HEALTH SERVICE. Analysis of environmental, samples chemical and radiochemical procedures. NERHL 64-1 (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone. Rad Health Data 5:620–628 (December 1964).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for Oak Ridge Area, Paducah Plant and Portsmouth Area Gaseous Diffusion Plant.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentration limits, are applicable to effluents released from AEC installations.

1. Oak Ridge Area[2]
July–December 1964

Union Carbide Nuclear Company,
Oak Ridge, Tennessee

The Oak Ridge Area is a complex made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge Area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 1. Airborne radioactive iodine is monitored in the immediate environment of plant areas by passing air through a cartridge containing activated charcoal.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the AEC Manual. AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, compiled by the Applied Health Physics Section of the Health Physics Division, Oak Ridge National Laboratory.

Table 1. Long-lived gross beta concentrations in air, Oak Ridge area, average concentrations in pCi/m³

Perimeter stations (see figure 1)	Number of samples	Second half 1964	Remote stations (see figure 2)	Number of samples	Second half 1964
HP-31	26	0.36	HP-51	26	0.45
HP-32	26	0.53	HP-52	25	0.47
HP-33	26	0.31	HP-53	26	0.50
HP-34	26	0.35	HP-54	26	0.53
HP-35	26	0.42	HP-55	26	0.45
HP-36	186	0.43	HP-56	26	0.38
HP-37	26	0.37	HP-57	26	0.41
HP-38	23	0.35			
Average		0.39	Average		0.46

Atmospheric contamination by uranium is determined by gross alpha measurements of continuous air samples taken at five locations within a five-mile radius from the ORGDP (figure 1). The data are summarized in table 2.

Table 2. Long-lived gross alpha activity in air[a] five miles from ORGDP, average concentrations in pCi/m ³

Direction from plant	Second half 1964
North	0.15
Northeast	0.16
Southwest	0.15

[a] Interpreted as uranium (natural)

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge Area. Four stations, remotely located with respect to Oak Ridge Operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge Area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and Clinch River. Liquid wastes originating at the

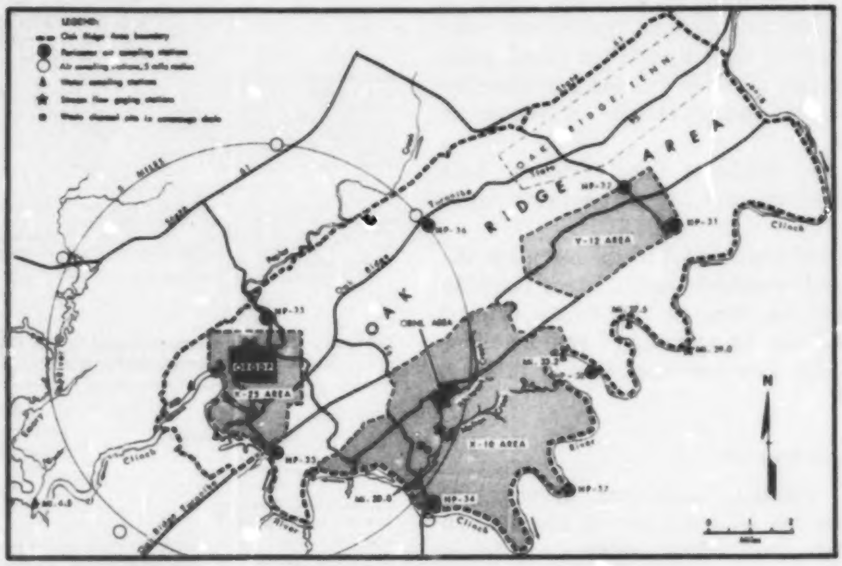

Figure 1. Oak Ridge area environmental sampling locations

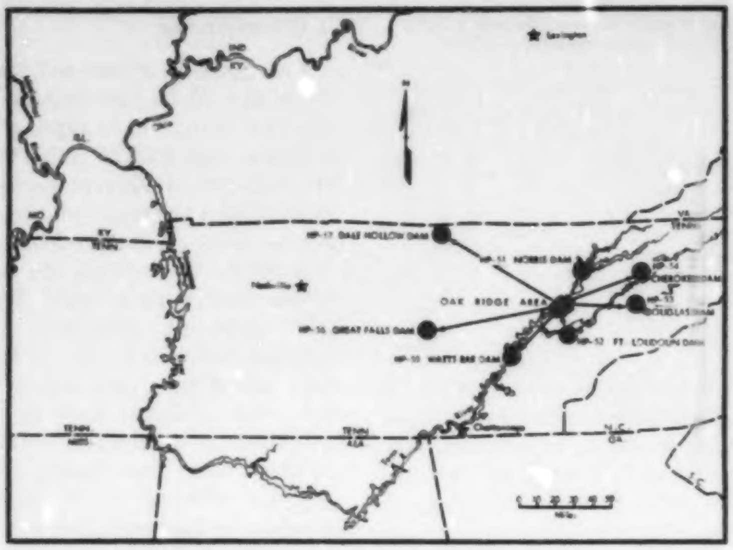

Figure 2. Remote air monitoring stations, Oak Ridge area

ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream-gaging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for long-lived beta emitters, uranium, and for transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system is such that no short-lived radionuclides are present. The averages are given in tables 3 and 4.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 5 in terms of mR/hr.

Table 3. Concentrations of major radionuclides in the Clinch River, average concentrations in pCi/liter

Radionuclide	Second half 1964		
	Location on Clinch River [a]		
	Mile 41.5 (Upstream)	Mile 20.8 [b] (Outfall)	Mile 4.5 (Downstream)
Strontium-90	0.9	0.9	1.9
Cerium-144	0.4	<0.1	0.6
Cesium-137	0.2	0.4	0.25
Ruthenium-106	2.0	17	13
Cobalt-60	[c] ND	2.1	2.1
Zirconium-60—niobium-95	[c] ND	<0.1	[c] ND
Gross beta	3.5	3.1	20

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] The concentrations at mile 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

[c] ND indicates none was detected.

Table 4. Uranium concentrations in the Clinch River, Oak Ridge Area, average concentrations in pCi/liter

Sampling location	Second half 1964	
	Number of samples [a]	Uranium concentration
Upstream from ORGDP	4	1.0
Downstream from ORGDP	4	1.0

[a] Normal sampling frequency is continuous, composited over one week.

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Table 5. External gamma radiation levels, Oak Ridge area, average exposure rates in mR/hr

Location	Exposure rates second half 1964 (mR/hr)
Solway Gate	0.014
Y-12 East Portal	0.012
Newcomb Road	0.013
Gallaher Gate	0.015
White Wing Gate	0.014
Average	0.013

Discussion of data

The average air contamination levels for gross beta activity, as shown by the continuous air-monitoring filter data for the immediate and remote environs of the plants, were 0.39 percent and 0.46 percent, respectively, of the maximum permissible concentration for populations in the neighborhood of a controlled area. These values are approximately 70 percent lower than those of the first half of 1964 and are no higher than the average of those measured in other areas of the United States and reported by the U.S. Public Health Service Radiation Surveillance Network for the period July through October, 1964.

The average concentration of iodine-131 in air in the immediate environs of the plants were 0.018 pCi/m^3. This is approximately 0.018 percent of the maximum permissible concentration for population in the neighborhood of a controlled area.

The average airborne alpha activity in the environs of the ORGDP, five miles from ORGDP, was 7.5 percent of the maximum permissible concentration for populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge Area were 7.0 pCi/liter and 5.4 pCi/liter, respectively. These values fall within the limits of FRC Range I if one assumes the average intake per individual to be 1 liter of milk per day. The maximum concentration observed in any one milk sample was 72 pCi/liter. This was observed in the immediate environs of the controlled area and was associated with the release of approximately 1,200 millicuries of iodine-131 from the plant stacks during a period of one week.

The average concentrations of strontium-90 in raw milk collected in the immediate and remote environs of the controlled area were 20 pCi/liter and 19 pCi/liter, respectively. These values approach the lower limit of FRC Range II for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and measured average concentration at mile 4.5 (near Kingston, Tennessee) were 31 pCi/liter and 20 pCi/liter, respectively. These values are 0.65 percent and 0.8 percent of the respective weighted average maximum permissible concentrations $(MPC)_w$. The average concentration of transuranic alpha emitters in the Clinch River at mile 20.8 was 0.009 pCi/liter, which is <0.001 percent of the weighted average $(MPC)_w$ values.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was <0.01 percent of the $(MPC)_w$ for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge Area averaged 0.013 mR/hr.

Conclusion

Comprehensive surveillance of radioactivity in the Oak Ridge environs indicated that a large part of the radioactivity detected continues to be the result of fallout from previous weapons testing. While some low-level radioactivity is being released to the environment in the form of gaseous and liquid wastes from plant operations, the resulting concentrations in both atmosphere and surface streams of the Oak Ridge environment are well below established maximum permissible concentrations and daily intake-guides for the neighboring population.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*
1962	*September 1963*
1963	*July 1964*
January–June 1964	*January 1965*

2. Paducah Plant, Calendar Year 1964

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Corporation, Nuclear Division for the Atomic Energy Commission. The diffusion plant, with the associated uranium hexafluoride manufacturing plant and uranium metal foundry, processes large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234, and protactinium–234, which may be concentrated by uranium recovery processes or uranium hexafluoride vaporization. The element, uranium, can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive element, and this provides a great incentive to recover as much in any situation as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is required to evaluate the effectiveness of such measures. The Paducah Plant environmental monitoring program provides for continuous air sampling at 4 stations around the plant perimeter fence, and at 5 stations located approximately 1 mile outside this fence. Sampling stations which were operated 5 miles outside the fence for the first half of 1964 were discontinued. Big Bayou Creek water is sampled continuously, and grab samples are collected at 5 locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for off-site exposure of the general population, are those listed in the AEC Manual (see footnote on page 391).

The standards specify that "radiation or radioactive materials outside a controlled area, and which have resulted from operations within the controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year." To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 6 through 10.

Table 6. Outdoor uranium air samples, Paducah Plant, 1964

Sample location [a]	Number of samples	Uranium alpha,[b] (pCi/m³)			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
AT PLANT PERIMETER FENCE					
N	52	0.32	<0.02	0.048	2.4
E	52	0.41	<0.02	0.046	2.3
S	52	0.20	<0.02	0.033	1.7
W	52	0.26	<0.02	0.029	1.5
Totals	208	0.41	<0.02	0.040	2.0
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	52	0.19	<0.02	0.026	1.3
E	52	0.21	<0.02	0.033	1.7
S	52	0.34	<0.02	0.037	1.9
W	52	0.31	<0.02	0.024	1.2
SE	52	0.37	<0.02	0.037	1.9
Totals	260	0.37	<0.02	0.031	1.6
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	0.03	<0.02	0.011	0.6
NW	26	0.13	<0.02	0.023	1.2
NE	26	0.12	<0.02	0.024	1.2
SE	26	0.07	<0.02	0.019	1.0
Totals	104	0.13	<0.02	0.019	1.0

[a] See map in figure 3.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.

[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.

[d] The concentration limit for natural uranium in air released to the environs is 2 pCi/m³.

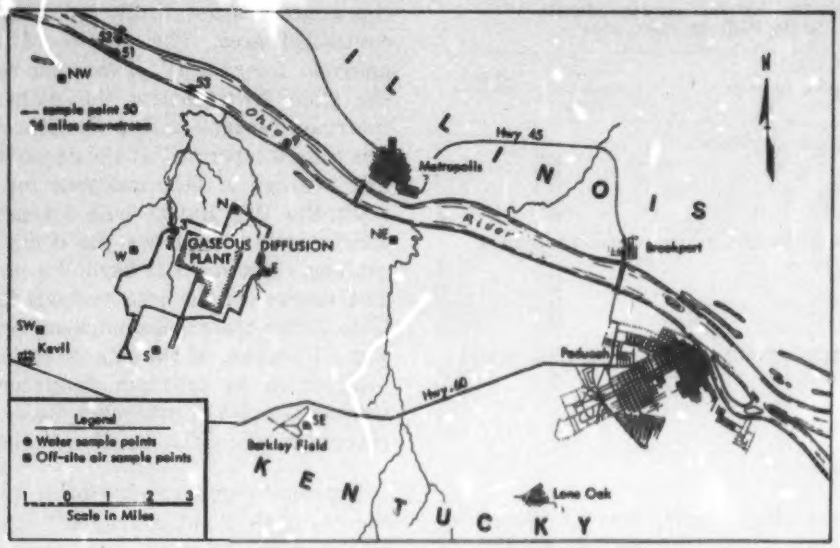

Figure 3. Water sampling locations, Paducah Gaseous Diffusion Plant

Table 7. Outdoor beta air samples, Paducah Plant, 1964

Sample location [a]	Number of samples	Beta (pCi/m³)			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
AT PLANT PERIMETER FENCE					
N	52	11	0.4	2.3	0.2
E	52	6	0.4	1.8	0.2
S	52	3	<0.1	0.9	0.09
W	52	5	0.4	0.9	0.09
Totals	208	11	<0.1	1.4	0.1
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE					
N	52	3	0.4	0.9	0.09
E	52	3	0.4	0.9	0.09
S	52	3	0.4	0.9	0.09
W	52	3	0.4	0.9	0.09
SE	52	3	0.4	0.9	0.09
Totals	260	3	0.4	0.9	0.09
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE					
SW	26	2	0.4	1.2	0.1
NW	25	3	0.9	1.5	0.2
NE	26	3	0.4	1.5	0.2
SE	26	3	0.4	1.3	0.1
Totals	104	3	0.4	1.4	0.1

[a] See map in figure 3.

[b] The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.

[c] The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit thorium-234, the daughter product of ^{238}U. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 8. Concentration of uranium in water, Paducah Plant, 1964

Sample location [a]	Number of samples	Uranium [b], pCi/liter			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
Big Bayou Creek 3	52	59	<1	15	0.1
Ohio River 9	11	1	<1	<1	<0.01
Composite of 50, 51, 52, & 53	11	2	<1	<1	<0.01

[a] See map in figure 3.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10^4 dis/sec.

[c] The minimum detectable concentration of uranium in water is 1 pCi/liter.

[d] The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

Table 9. Concentration of beta emitters in water, Paducah Plant, 1964

Sample location [a]	Number of samples	Beta emitters, pCi/liter			Mean as percent of RCG [c]
		Maximum	Minimum [b]	Mean	
Big Bayou Creek 3	52	2100	<100	280	1.4
Ohio River 9	11	700	<100	200	1.0
Composite of 50, 51, 52 & 53	11	1800	<100	400	2.0

[a] See map in figure 3.

[b] The minimum detectable amount of beta emitters in water is 100 pCi/liter.

[c] The concentration limit for the daughter products of uranium in water released to the environs is 20,000 pCi/liter.

Air samples were collected continuously at each of 4 stations at the plant perimeter fence, at 5 stations at about 1 mile outside the plant, and at 4 stations located about 5 miles from the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta activity.

The average alpha count—interpreted as uranium—the most likely source of activity, of

Table 10. External gamma radiation levels, Paducah Plant, 1964

Air sampling location [a]	Total number of readings	Gamma, mR/hour
AT PLANT PERIMETER FENCE		
N	12	0.02
E	12	0.02
S	12	0.02
W	12	0.02
Total	48	0.02
ABOUT ONE MILE OUTSIDE PLANT PERIMETER FENCE		
N	12	0.02
E	12	0.02
S	12	0.02
W	12	0.02
SE	12	0.02
Total	60	0.02
ABOUT FIVE MILES OUTSIDE PLANT PERIMETER FENCE		
SW	6	0.02
NW	6	0.02
NE	6	0.02
SE	6	0.02
Total	24	0.02

[a] See map, figure 3.

the 572 air samples collected was 1.6 percent of the concentration limit for people residing in the vicinity of a controlled area.

The mean beta count of the 572 samples was 0.12 percent of the concentration limit for the daughter products of uranium in air beyond a controlled area.

The average of uranium analyses of weekly water samples collected by a continuous water sampler in the Big Bayou was 0.1 percent of the concentration limit for water beyond a controlled area. The results of the uranium analyses for each of 11 samples collected from the Ohio River below the plant at monthly intervals (except during the March flood) was less than 0.1 percent of the concentration limit. The average of beta analyses for the samples from the Big Bayou was 1.4 percent of the concentration limit for the decay products of uranium-238 in water beyond a controlled area. The average of the beta analysis for samples of Ohio River water downstream from the plant was 1.5 percent of the concentration limit when interpreted as uranium daughters. However, similar samples of upstream water averaged 1.5 percent of the concentration limit.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*
1962	*September 1963*
1963	*July 1964*
January–June 1964	*February 1965*

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3. Portsmouth Area Gaseous Diffusion Plant,[3] Calendar Year 1964

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

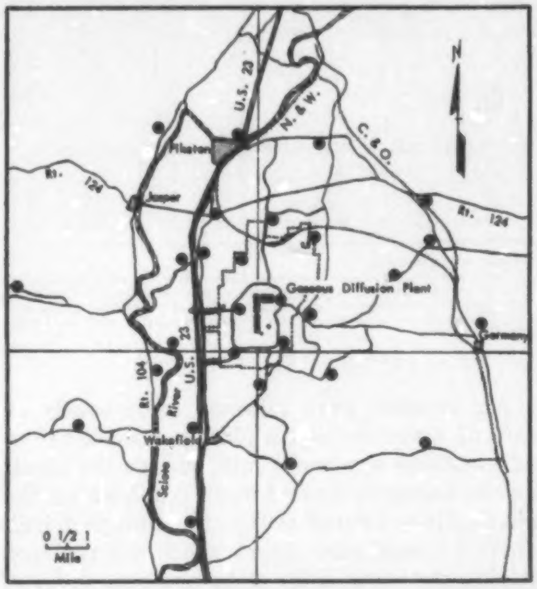

Figure 4. Air sampling locations, Portsmouth Gaseous Diffusion Plant

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[3] Data summarized from B. Kalmon: Environmental Radiation Levels and Concentrations, 1964, GAT-450 (March 1, 1965).

Continuous air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 14 stations within 5 miles of the plant.

Average alpha and beta-gamma concentrations in air and water are summarized in table 11. The external gamma levels are measured at the air sampling locations shown in figure 4 and the results included in table 11.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
1962	*May 1963*
1963	*July 1964*

Table 11. Environment radioactivity, Portsmouth plant, 1964

Measurement	Unit	1964				
		No. of samples	Maximum	Minimum	Average	Percent maximum permissible for average
Air (alpha concentration)	pCi/m^3	251	0.9	<0.1	<0.1	<5.0
Air (beta-gamma concentration)	pCi/m^3	251	8.5	<0.1	1.5	1.5
Water (alpha concentration)	pCi/liter	150	198.2	<0.5	13.5	0.07
Water (beta-gamma concentration)	pCi/liter	144	90.2	<14.0	14.0	0.07
External beta-gamma [a]	mRad/hr	251	0.12	<0.01	0.04	48

[a] Measurements were made with open shield Geiger-Mueller tube one foot above ground. The three-foot rate (not shown) was experimentally determined to average two-thirds of the one-foot rate.

REPORTED NUCLEAR DETONATIONS, JUNE 1965

During June 1965 two United States nuclear tests were announced by the Atomic Energy Commission. The tests conducted underground at the Commission's Nevada Test Site on June 11 and June 16, 1965, were each of low yield (less than 20 kilotons).

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

AUTORADIOGRAPHIC EXAMINATION OF AIRBORNE FALLOUT FOR OCTOBER–NOVEMBER 1964. *Shleien, B., L. Bernard, and A. G. Friend* (Division of Radiological Health). *Radiological Health Data, Vol. 6, 1965*, pp. 419-421.

Following the detonation of a nuclear device by Communist China, airborne particulates collected from surface air were examined by autoradiographic techniques at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. Autoradiography, combined with beta counting and optical microscopy, was used to compare the number of radioactive particles, their specific activity, and their gross beta activity. The concentration of radioactive foci during this study varied from 0.10 to 1.36 per m^3.

EFFECT OF VARIETY ON THE ACCUMULATION OF STRONTIUM–90 IN WHEATS AND THEIR MILLED PRODUCTS. *Anderson, R. A. and V. F. Pfeifer* (Agricultural Research Service, U. S. Department of Agriculture). *Radiological Health Data, Vol. 6, August 1965*, pp. 438-440.

As another phase of continuing studies to develop methods for reducing radionuclide levels in wheat and milled wheat products, five varieties of wheat grown in Kansas and 10 varieties grown in Nebraska were investigated and the results compared by variety and growing areas. Information presented shows that uptake of strontium–90 from fallout and soil absorption is dependent on wheat variety as well as location. Milled products from two varieties grown in one location under identical growing conditions, but exhibiting high and low levels of strontium–90 uptake, showed significant differences in the strontium–90 in the shorts and bran fractions; the flours were about the same.

MEASUREMENT OF IODINE–131 IN BOVINE THYROIDS. *Falter, K. H.* and *G. Murray*. (Division of Radiological Health), *Radiological Health Data, Vol. 6, August 1965*, pp. 451-455.

To augment existing radiation surveillance data, the Division of Radiological Health has collected bovine thyroids for iodine–131 analysis between September 1962 and January 1964. A pilot study was conducted in September 1962 and an operational study was carried out between January 1963 and January 1964. During the operational period, milkshed average iodine concentrations ranged from a high value of 202 picocuries per gram of thyroid in January 1963 to the limit of reliability of measurements by the system used, but even in the presence of this contamination, bovine thyroid analysis was found to be more than one order of magnitude more sensitive than milk analysis for determining environmental levels of iodine–131.

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Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess total human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

1. Radiation Surveillance Network
April 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about five hours after the end of the sampling period to allow for decay of the naturally occurring radon daughters. The daily field readings are submitted to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are observed, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters four inches in diameter. About 1800 cubic meters of air are drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a strontium-90-yttrium-90 standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 2000 cpm or higher. The initial four-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the day

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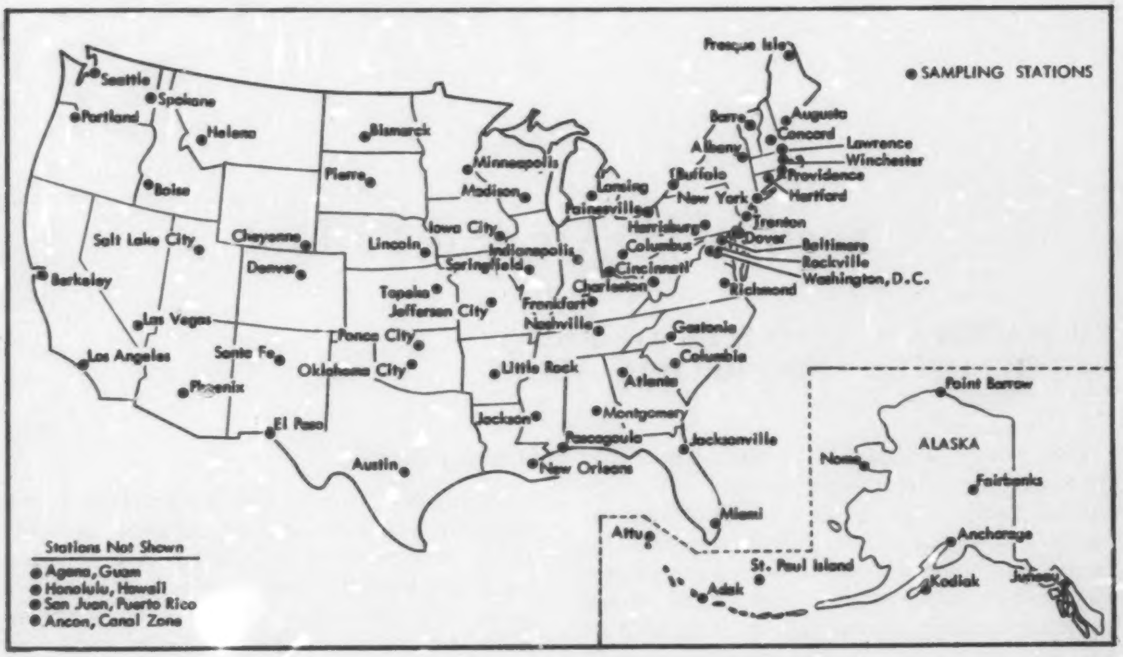
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Santa Fe
El Paso
Cheyenne
Denver
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Springfield
Indianapolis
Little Rock
Jackson
New Orleans
Pascagoula
Montgomery
Atlanta
Jacksonville
Miami
Nashville
Frankfort
Charleston
Cincinnati
Columbus
Lansing
Painesville
Buffalo
Harrisburg
Gastonia
Columbia
Richmond
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

of collection.[1] The April 1965 average gross beta concentrations in air for RSN stations are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Radioactivity in precipitation

Continuous sampling for radioactivity in total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nCi/m^2, C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month. Total depths of precipitation and deposition of radioactivity during April 1965 are presented in table 1.

Discussion

During April 1965, 20 air samples and 2 precipitation samples were analyzed by gamma spectrometry. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the gamma scan data. As a matter of policy these samples are not generally destructively analyzed. Nineteen of the air samples and both precipitation samples contained long-lived nuclides such as ^{7}Be, ^{54}Mn, ^{137}Cs, ^{106}RuRh, ^{144}CePr, ^{65}Zn, and ^{125}Sb in small quantities. In

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

Table 1. Gross beta activity in surface air and precipitation, April 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity, pCi/m^3			Last profile in *RHD*	Total depth (mm)	Total deposition (nCi/m^2)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	0.66	<0.10	0.29	May 65	27.1	5.5
Alaska:	Adak	27	0.49	<0.10	<0.17	Nov 64	[b]	[b]
	Anchorage	30	0.43	<0.10	<0.18	May 65	1.7	0.3
	Attu Island	25	0.27	<0.10	<0.15	Dec 64		
	Fairbanks	25	0.41	<0.10	<0.16	Jun 65	7.0	1.6
	Juneau	10	0.51	<0.10	<0.25	Sep 64	36.0	27.6
	Kodiak	17	0.64	<0.10	<0.19	Aug 65		
	Nome	15	0.20	<0.10	<0.12	Feb 65		
	Point Barrow	30	0.28	<0.10	<0.12	Jan 65		
	St. Paul Island	25	0.31	<0.10	<0.15	Mar 65		
Ariz:	Phoenix	28	1.08	0.15	0.44	Sep 64		
Ark:	Little Rock	26	0.62	<0.10	0.28	Jun 65	19.9	4.0
Calif:	Berkeley	24	0.45	<0.10	<0.15	Aug 65	92.7	18.6
	Los Angeles	30	0.44	<0.10	0.23	Feb 65	190.0	38.1
C. Z:	Ancon	11	0.27	<0.10	<0.13	Aug 65		
Colo:	Denver	29	1.11	<0.10	0.36	Aug 65	28.9	8.3
Conn:	Hartford	30	0.49	<0.10	<0.23	Oct 64	64.5	16.0
Del:	Dover	19	0.61	<0.10	0.26	May 65		
D. C:	Washington	28	0.61	<0.10	0.28	Feb 65	34.7	8.2
Fla:	Jacksonville	30	0.54	<0.10	0.27	Jun 65	51.6	11.9
	Miami	21	0.83	0.17	0.45	Oct 64	34.5	7.0
Ga:	Atlanta	2	0.13	<0.10	<0.11	Apr 65		
Guam:	Agana	29	0.88	<0.10	0.32	Apr 65		
Hawaii:	Honolulu	30	0.41	<0.10	<0.16	Dec 64	81.9	16.5
Idaho:	Boise	28	196.70	<0.10	7.30	Dec 64	66.2	13.3
Ill:	Springfield	29	0.69	<0.10	0.25	Feb 64		
Ind:	Indianapolis	27	0.45	<0.10	0.26	Apr 65	123.4	25.0
Iowa:	Iowa City	29	0.66	<0.10	0.27	Aug 65	184.6	37.4
Kans:	Topeka	25	0.39	<0.10	0.19	May 65	59.4	12.0
Ky:	Frankfort	26	0.66	<0.10	0.36	Feb 65	37.4	7.5
La:	New Orleans	30	0.46	<0.10	0.25	Feb 65	26.6	6.3
Maine:	Augusta	22	0.65	<0.10	0.28	Mar 65	80.6	16.1
	Presque Isle	29	0.47	<0.10	0.25	Aug 65		
Md:	Baltimore	21	0.48	<0.10	0.26	Oct 64	40.0	10.0
	Rockville	13	0.38	<0.10	0.22	Jan 65		
Mass:	Lawrence	30	0.52	<0.10	0.26	May 65	87.9	19.2
	Winchester	30	0.58	<0.10	0.31	Dec 64	77.1	16.0
Mich:	Lansing	30	0.65	<0.10	0.31	Jan 65	5.9	1.4
Minn:	Minneapolis	22	0.32	<0.10	<0.17	Apr 65	105.7	23.9
Miss:	Jackson	29	1.01	0.11	0.34	Dec 64	21.4	4.3
	Pascagoula					Dec 64		
Mo:	Jefferson City	29	0.61	<0.10	<0.22	Apr 65	100.6	20.3
Mont:	Helena	29	22.19	<0.10	1.19	Nov 64	22.8	26.50
Nebr:	Lincoln	20	2.43	<0.10	0.49	Mar 65	56.8	11.30
Nev:	Las Vegas	27	0.91	0.12	0.38	Jun 65	48.8	16.8
N. H:	Concord	21	0.64	<0.10	0.33	Feb 65		
N. J:	Trenton	30	0.60	<0.10	0.27	Mar 65	21.7	4.5
N. Mex:	Santa Fe	28	0.57	<0.10	0.27	Nov 64	16.3	3.6
N. Y:	Albany	22	0.55	<0.10	0.29	Apr 65	53.0	10.6
	Buffalo	27	0.79	<0.10	0.37	Aug 65		
	New York	25	0.49	<0.10	0.23	Dec 64		
N. C:	Gastonia	29	0.58	<0.10	0.29	Aug 65	117.3	23.5
N. Dak:	Bismarck	30	0.54	<0.10	<0.19	Jan 65	59.5	12.2
Ohio:	Cincinnati	17	0.45	<0.10	0.26	May 65		
	Columbus	28	0.80	0.11	0.45	Mar 65	166.0	34.7
	Painesville	30	0.72	<0.10	0.34	Oct 64	38.1	15.0
Okla:	Oklahoma City	30	0.71	<0.10	0.26	Jan 65	25.0	5.0
	Ponca City	27	0.41	<0.10	<0.16	Oct 64	61.1	12.8
Ore:	Portland	26	0.59	0.12	0.33	Mar 65	42.6	8.5
Pa:	Harrisburg	25	0.52	<0.10	<0.23	Apr 65	12.0	2.4
P. R:	San Juan	28	0.44	<0.10	0.20	Mar 65	82.9	16.5
R. I:	Providence	23	0.49	<0.10	<0.22	Jan 65	63.9	14.1
S. C:	Columbia	25	0.42	<0.10	0.22	Dec 64	70.7	14.2
S. Dak:	Pierre	27	0.52	<0.10	<0.20	Sep 64	14.1	6.7
Tenn:	Nashville	30	0.75	<0.10	0.32	Jan 65	119.8	27.0
Tex:	Austin	29	0.76	<0.10	0.25	May 65	46.2	9.3
	El Paso	27	1.11	0.20	0.54	Jan 65		
Utah:	Salt Lake City	27	0.64	<0.10	0.29	Feb 65	65.2	13.1
Vt:	Barre	26	0.70	<0.10	0.36	Jun 65	43.3	8.7
Va:	Richmond	30	0.56	<0.10	0.23	Jun 65	68.8	13.8
Wash:	Seattle	30	0.32	<0.10	<0.17	May 65	84.6	18.5
	Spokane	28	0.48	<0.10	0.26	Apr 65	24.8	7.0
W. Va:	Charleston	28	0.61	<0.10	0.31	Dec 64	161.1	32.3
Wis:	Madison	30	0.56	<0.10	0.26	Jun 65	91.1	27.6
Wyo:	Cheyenne	30	0.70	<0.10	0.34	Jun 65	10.8	3.5
Network summary [c]		1909	196.70	<0.10	<0.37		61.4	14.1

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

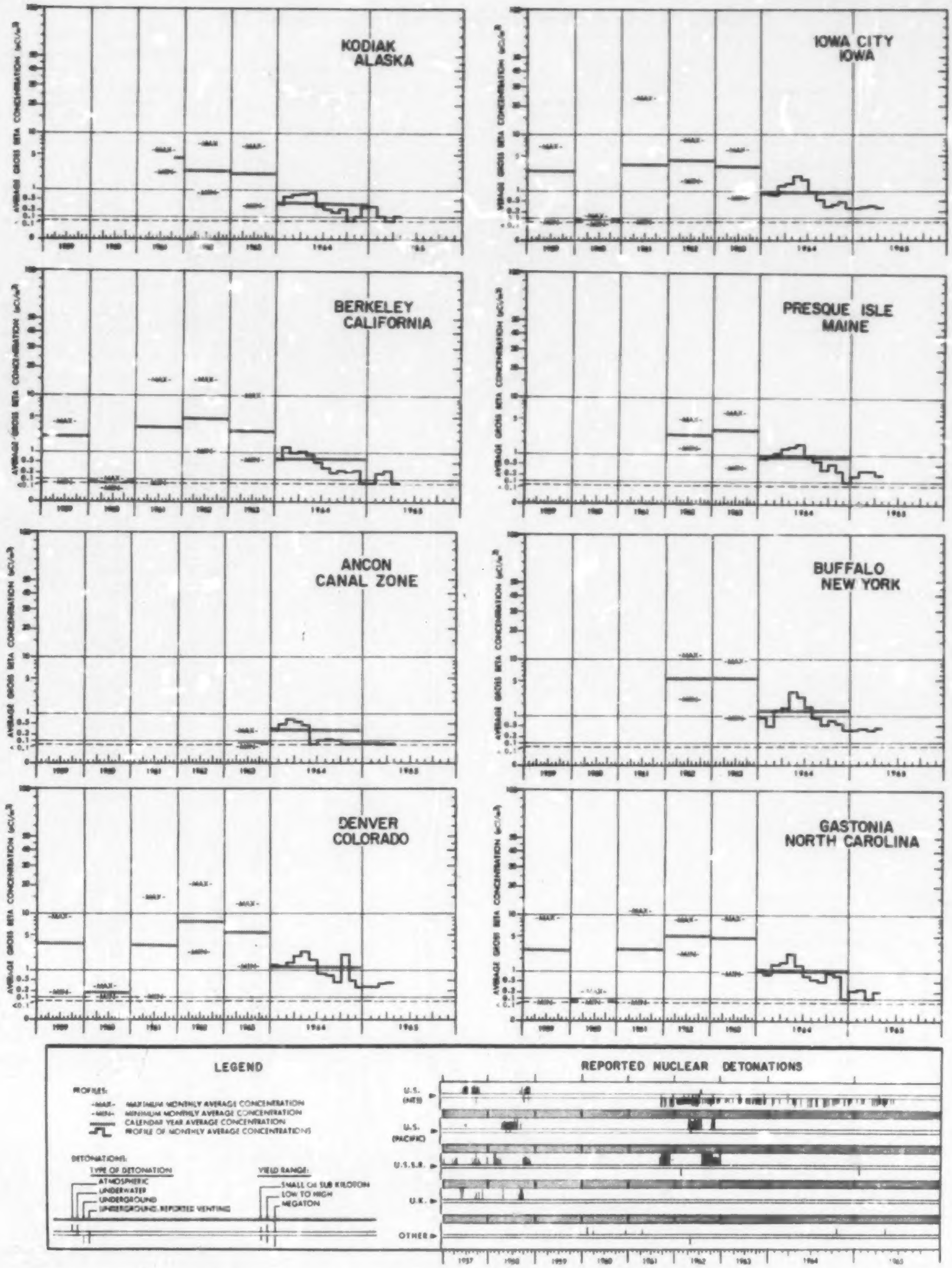

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–April 1965

addition twelve air samples and both of the precipitation samples contained fresh fission products in identifiable quantities. Fresh fission products were identified in the daily samples from the network stations, as listed below:

Boise, Idaho	April 15, 16, and 17
Helena, Montana	April 16, 17, and 19
Cheyenne, Wyoming	April 16
Phoenix, Arizona	April 16
Denver, Colorado	April 16
Oklahoma City, Okla.	April 18
Lincoln, Nebraska	April 19
Jackson, Mississippi	April 22

Only two air samples were of sufficient activity to obtain an estimated age of the fresh fission products. These samples, collected on April 16 at Boise, Idaho, and Helena, Montana, exhibited observed ages of two days and one day, respectively.

The time relationship of the appearance of the fresh fission product material in these samples is consistent with the release of small quantities of radioactivity associated with the nuclear test conducted in Nevada on April 14, 1965, as reported in *Radiological Health Data*, page 289, May 1965.

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2. Canadian Air Monitoring Program[2] April 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–9*).

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa.

For analysis, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a ^{90}Sr–^{90}Y standard. Four successive measurements are made on each filter to permit correction for natural activity and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for April 1965 are given in table 2.

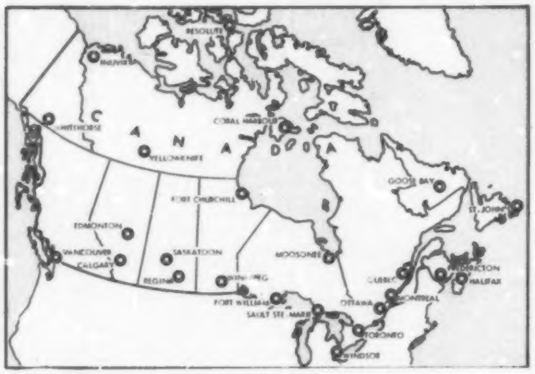

Figure 3. Canadian air and precipitation sampling stations

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is then ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a strontium-90—yttrium-90 source. Gross beta activities for April 1965 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

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[2] This report was prepared from information and data in the May 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Gross beta activity in surface air and precipitation, Canada, April 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity, pCi/m³			Average concentration, (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	30	0.7	0.1	0.3	301	3.7
Coral Harbour	29	0.5	0.1	0.3	141	1.7
Edmonton	30	0.3	0.1	0.2	264	4.3
Ft. Churchill	27	0.4	0.1	0.2	109	2.0
Ft. William	30	0.6	0.1	0.3	177	7.7
Fredericton	30	0.6	0.1	0.3	107	5.8
Goose Bay	30	0.5	0.1	0.3	139	5.9
Halifax	30	0.5	0.0	0.2	154	6.5
Inuvik	30	0.4	0.1	0.2	107	2.1
Montreal	30	0.7	0.0	0.4	95	6.0
Moosonee	30	0.5	0.1	0.3	292	4.4
Ottawa	30	0.5	0.0	0.3	119	7.7
Quebec	30	0.5	0.1	0.3	157	7.7
Regina	30	0.5	0.0	0.3	260	4.4
Resolute	29	0.5	0.2	0.3	108	0.8
St. John's, Nfld	29	0.5	0.0	0.2	98	10.0
Saskatoon	30	0.2	0.1	0.2	304	3.5
Sault Ste. Marie	29	0.8	0.0	0.4	241	10.2
Toronto	29	0.6	0.1	0.3	197	10.8
Vancouver	30	0.4	0.1	0.2	211	10.9
Whitehorse	30	0.5	0.0	0.2	321	1.6
Windsor	30	0.6	0.0	0.3	245	11.9
Winnipeg	30	0.6	0.0	0.2	136	8.8
Yellowknife	30	0.5	0.1	0.2	108	1.5
Average		0.5	0.4	0.3	187	5.8

3. Mexican Air Monitoring Program April 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*10–14*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new radiation surveillance network. This consists of 17 stations (figure 4), 12 of which are located at airports and operated by airline personnel. The remaining 5 stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Merida, the Institute de Zonas Deserticas of the University of Baja, California, respectively.

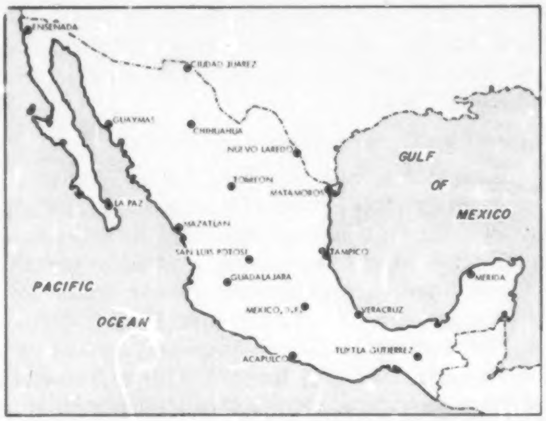

Figure 4. Fallout network sampling stations in Mexico

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Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during April 1965 are presented in table 3.

Table 3. Gross beta activity of airborne particulates, April 1965

Station	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	6	0.1	<0.1	0.1
Ciudad Juárez	11	0.4	0.1	0.2
Chihuahua	10	0.6	0.1	0.2
Ensenada	12	0.3	0.1	0.2
Guadalajara	12		0.1	0.1
Guaymas	22	0.5	0.1	0.2
La Paz	10	0.5	0.1	0.3
Matamoros	8	0.2	<0.1	0.1
Mazatlán	1			
Mérida	10	0.1	<0.1	0.1
México, D.F.	8	0.1	<0.1	0.2
Nuevo Laredo	7	0.3	0.1	0.2
San Luis Potosí	10	0.1	<0.1	<0.1
Tampico	19	0.4	0.1	0.2
Torréon	17	0.3	<0.1	0.1
Tuxtla Gutiérrez				
Veracruz				

[a] Blanks indicate stations temporarily shut down.

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4. Pan American Air Sampling Program April 1965

Pan American Health Organization and *Public Health Service*

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; and in Trinidad, West Indies, by the University of the West Indies. The Kingston station began operation in March 1964, and the others were started near the end of 1962.

The April 1965 air monitoring results from the four participating countries are given in table 4.

Table 4. Gross beta activity in air, April 1965 (Concentrations in pCi/m³)

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	19	0.53	<0.10	0.27
Caracas, Venezuela	18	0.12	<0.10	<0.10
Lima, Peru	17	0.10	<0.10	<0.10
Santiago, Chile	30	0.19	<0.10	<0.10
Trinidad, West Indies	20	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

5. Gross beta activity in air, North America April 1965

From January 1963 through March 1965, monthly average concentrations of airborne gross beta activity in Canada and the United States were presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*15*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*16*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

In recent months, airborne gross beta activities have declined to such low levels that isogram comparisons are no longer meaningful. Before comparison with each other, the data from different networks must be multiplied by appropriate intercalibration factors. For example, if the Canadian data are considered as unity, the RSN and Pan American data must be multiplied by the intercalibration factor, 1.28, and the Mexican data must be multiplied by 0.81.

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(*2*) WAY, K. and E. P. WIGNER. The rate of decay of fission products. Phys Rev 73:1318–30 (June 1, 1948).

(*3*) BURRUS, W. R. Unscrambling scintillation spectrometer data. IRE Trans Nucl Sci NS–7, 2–3:102–111 (1960).

(*4*) COVELL, D. F. Determination of gamma ray abundance directly from total absorption peak. Anal Chem 31:1785–1790 (November 1959).

(*5*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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AUTORADIOGRAPHIC EXAMINATION OF AIRBORNE FALLOUT FOR OCTOBER-NOVEMBER 1964

B. Shleien, L. Bernard, and A. G. Friend[1]

Prior to and following the October 1964 detonation of a nuclear device on the Chinese mainland, autoradiographic techniques were used to study radioactive particulates in surface air at the Northeastern Radiological Health Laboratory in Winchester, Massachusetts. Both the number of radioactive particles and the gross beta activity per unit volume of air were investigated. This study was so designed because other ground level surveillance systems, operated by the Public Health Service during this period, included airborne radioactivity measurements but not determinations of the physical and radiological character of individual particles from weapons test debris.

This report presents both results of this study and comments on the usefulness of the autoradiographic approach as an indicator of the aerial intrusion of fresh fission products, especially where the overall increase in airborne gross beta activity is small.

Collection of particulates

Samples were collected using a positive displacement pump having a sampling rate of 1.3 cubic meters per minute[2] and fitted with an 8 x 10-inch (20.3 x 25.4-cm) filter holder. Collections were made on a membrane filter (pore size 0.8 micron). Selection of this filter was based on the fact that collected particles are deposited on the surface of the collecting medium. Sampling periods varied from one to three days. The total volume of air sampled ranged from 1000 to 4000 cubic meters per sample.

Method of film exposure

Several authors have described methods for autoradiographic examination of particles thus collected (*1–3*). The method consists of placing the filter on a holder, particles upward, in contact with "no-screen" x-ray film, and allowing exposure in darkness for a sufficient length of time to yield observable film darkening. When fresh fission product debris was indicated, the exposure time was standardized at seven days. The film holder was constructed so that the developed film could be realigned with the filter and the portions of the filter containing radioactive foci removed. The film was developed by standard techniques. Pressure was maintained over the film by insertion of several thicknesses of corrugated cardboard between the film and the top of the exposure chamber.

Counting the radioactive foci

Following development of the film, 2-mm diameter circles containing exposed areas, together with portions of the filter immediately below the film, were punched out. The filter disks were counted in a low-background anticoincidence beta counter. Areas of the filter which did not contain radioactive foci were counted to establish counter and filter beta activity "background." The diameter of the exposed spots was measured with a graticule and magnifier. The boundary of a focus was taken to be the periphery of absolute darkening and the beginning of the grayish area. Two arbitrary ranges of activity were established: (1) activities greater than 0.3 counts per minute, causing spot diameters between 0.25 and 0.5 millimeters, and (2) activities greater than 1 count per minute, causing spot diameters above 0.5 millimeters.

Concurrently with sampling for autoradiographic examination, the airborne gross beta activity was determined. Sampling apparatus

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[1] Dr. Shleien is Staff Officer, Mr. Bernard is a Physical Science Aide, and Dr. Friend is the Project Officer, Engineering Program, DRH, Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

[2] Sampling rate is measured at standard conditions of temperature and pressure.

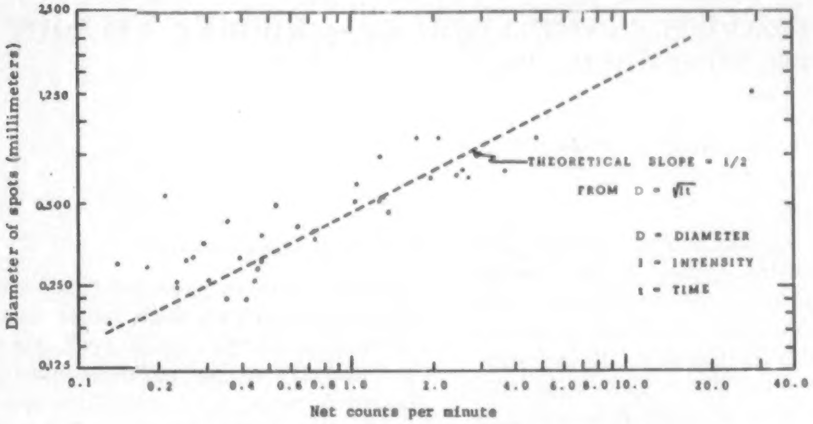

Figure 1. Diameter of autoradiographic spots *vs.* beta activity, sample for October 23-26, 1964

for this determination consisted of a self-lubricating vacuum sampling pump (sampling rate, 28–56 liters per minute), a flow meter and manometer, and a membrane filter holder (*4*). The sampler was capable of sampling 30 cubic meters of air in a 24-hour period through a 47-millimeter diameter membrane filter. Gross beta counting of air particulates was performed four days after the end of sampling to allow for radon and thoron daughter decay. Counting was done in a thin-window internal proportional counter, standardized with cesium-137.

To determine the number of radioactive foci relative to non-radioactive particles present, particles collected on a membrane filter were counted with an optical microscope at 100x, 430x, and 1000x (oil immersion). A 3200-square micron area of the filter was counted. This method is somewhat limited in that only particles above approximately 0.3 micron can be resolved.

Results and discussion

An air particulate sample collected prior to the intrusion of fresh fission products from October 16–19, 1964, showed no evidence of radioactive foci upon autoradiographic examination. During this period, gross beta activity of surface air particulates was 0.28 pCi/m^3. For a sample collected from October 19–21, 1964, two radioactive foci were isolated (0.7 foci/1000m^3); the gross beta activity for this period being 0.14 pCi/m^3. A one-day sample collected on October 21, 1964, indicated the presence of 178 foci/1000m^3 and a gross beta activity of 0.38 pCi/m^3. This level of gross beta activity is within the limits of daily variations, but the presence of fresh fission products was confirmed by gamma spectral analysis. Thereafter, there was a rise in both the number of radioactive foci and the gross beta activity.

The air particulates sample collected from October 23–26, 1964, was used to relate spot diameter to beta activity and to check the validity of the beta counting and spot measuring techniques. The diameter, D, of the spot is theoretically related to activity and length of exposure by the equation $D = \sqrt{It}$, where I equals the intensity (activity) of the radiation, and t the length of exposure (*5*). Since t was held constant, D is proportional to $\sqrt{I}$.

The diameter of the spots plotted against the β activity on log-log paper was found to approximate the theoretically expected slope of 0.5 (figure 1). The correlation coefficient between activity and spot size was 0.55 and the 95 percent confidence interval for the correlation coefficient was $0.40 \leq r \leq 0.79$.

Figure 2 illustrates the variation in airborne gross beta activity, the number of radioactive foci present, and the relative distribution of activity per particle. The maximum air activity occurred during the collection period October 28–29, 1964 (2.38 pCi/m^3), at which time the number of radioactive foci numbered 1365/1000m^3. For the most part, increases in activity were accompanied by increases in the number of foci per unit volume of air. Several exceptions occurred, at which times lower numbers of radioactive foci were compensated for by a higher percentage of "hotter" particles.

During these periods, the percentage of foci with larger diameters increased, indicating an increased specific activity per particle. The most active particle isolated was from the sample collected October 23–26, 1964, and was estimated to contain about 30 pCi of beta activity. The radioactive particle concentrations determined during this study were within the range of 0.13 radioactive particles/m^3 to 2.2 radioactive particles/m^3, as reported by others (*6*, *7*).

In an earlier investigation of the particle size of airborne gamma emitting radionuclides, no relationship could be found between the amount of radioactivity collected in a particular size fraction and particle (radioactive and non-radioactive) diameter, weight, surface area, and number in the size fraction (*8*). It was theorized in that report that this was due to the relatively small number of radioactive particles compared to the number of non-radioactive particles. This is borne out by the data presented in table 1, which compare the number of radioactive foci (each focus is assumed to be due to a single radioactive particle) to the total number of particles present as determined by optical microscopic counting.

Table 1. Concentration of radioactive foci and total particles present in surface air, October 23–November 12, 1964

Radioactive foci/m^3			Total number of particles/m^3		Ratio: radioactive foci
Date	Number	Average number for period	Date	Number x 10^9	total number of particles
10/23–26	0.42	0.42	10/23–26	1.11	3.8×10^{-9}
10/26–28 10/28–30	0.12 1.36	0.74	10/26–29	1.78	4.2×10^{-9}
10/30–11–1 11/1–3	0.51 0.12	0.31	11/1–4	1.82	1.7×10^{-9}
11/10–12	0.10	0.10	11/11–14	1.34	7.5×10^{-10}

Conclusions

It can be stated that the autoradiographic examination of airborne radioactive particles during an intrusion of fresh fallout indicated changes in the specific activity per particle and in the concentration of radioactive particles relative to gross beta activity. As a result of this study, the authors believe that autoradiographic techniques are a reliable method for substantiating the presence of fresh fallout from an atmospheric nuclear detonation, especially under conditions where the rise in airborne gross beta activity is small.

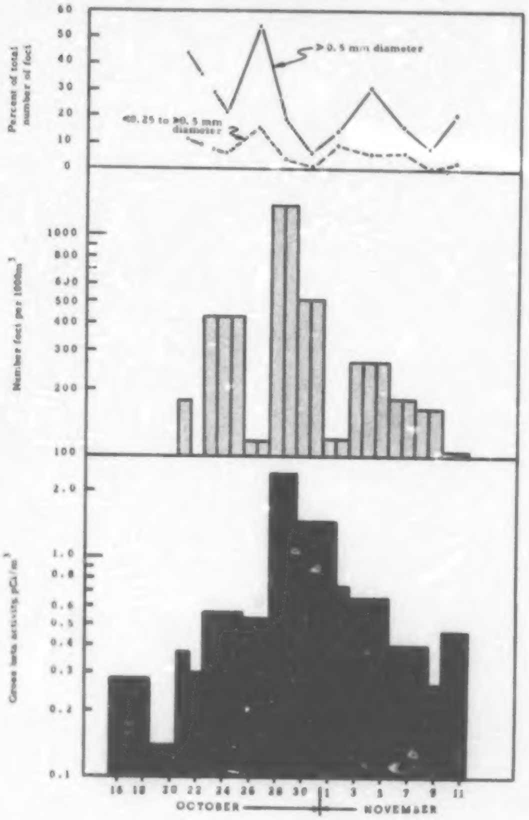

Figure 2. Results of autoradiography and gross beta activity from October 16 to November 12, 1964

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, April 1965

Division of Radiological Health, and
Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analysis.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Table 1. Analytical errors associated with estimated concentrations for selected radionuclides in milk

Nuclide	Estimated concentration (pCi/liter)	Error [a] (pCi/liter)	Estimated concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	±5	50 or greater	±10
Strontium-90	0 to 20	±2	20 or greater	±10

[a] Two standard deviations (σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for April 1965 (actual reporting period is March 28, 1965 to April 24, 1965). Barium–140 results are not presented because the monthly average concentrations in milk were less than 10 pCi/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

The distribution of monthly averages for strontium–90 and cesium–137 network stations for November 1964 through April 1965 are compared in tables 3 and 4. The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960–March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*). An annual summary for 1964 appeared in the April 1965 *RHD* (*3*).

Discussion of data

Neither iodine–131 nor barium–140 were found in PMN samples collected during the month of April 1965. Iodine–131 had last been detected in 45 milk samples during the period October 26 through November 30, 1964, and was attributed to the detonation of a nuclear device on the Chinese Mainland on October 16, 1964.

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[2] The conversion factor is 1.18 milligrams K/pCi^{40}K.

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, April 1965 and the first quarter 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter	April 1965	First quarter	April 1965	First quarter	April 1965	First quarter	April 1965
Ala:	Montgomery	1.19	1.18	<5	<5	19	23	55	60
Alaska:	Palmer	1.18	1.17	<5	<5	17	21	60	75
Ariz:	Phoenix	1.20	1.18	<5	<5	6	6	25	20
Ark:	Little Rock	1.18	1.16	<5	<5	34	38	70	75
Calif:	Sacramento	1.26	1.32	<5	<5	7	8	35	40
	San Francisco	1.27	1.23	<5	<5	8	12	35	45
C. Z:	Cristobal	1.14	1.13	<5	<5	5	4	40	40
Colo:	Denver	1.27	1.28	<5	<5	18	19	70	80
Conn:	Hartford	1.12	1.12	<5	<5	16	16	90	90
Del:	Wilmington	1.15	1.15	<5	<5	19	19	80	80
D. C:	Washington	1.17	1.18	<5	<5	17	16	60	60
Fla:	Tampa	1.18	1.16	<5	<5	13	12	160	170
Ga:	Atlanta	1.19	1.16	<5	<5	26	31	90	100
Hawaii:	Honolulu	1.18	1.21	<5	<5	11	12	65	60
Idaho:	Idaho Falls	1.21	1.26	<5	<5	21	20	110	100
Ill:	Chicago	1.12	1.12	<5	<5	17	16	90	95
Ind:	Indianapolis	1.19	1.18	<5	<5	17	18	75	65
Iowa:	Des Moines	1.20	1.26	<5	<5	22	23	60	70
Kans:	Wichita	1.24	1.26	<5	<5	18	20	55	55
Ky:	Louisville	1.17	1.15	<5	<5	22	24	60	55
La:	New Orleans	1.23	1.20	5	<5	43	47	80	100
Maine:	Portland	1.14	1.12	<5	<5	23	22	135	140
Md:	Baltimore	1.16	1.16	<5	<5	18	18	65	70
Mass:	Boston	1.16	1.15	<5	<5	23	22	140	150
Mich:	Detroit	1.15	1.14	<5	<5	16	17	85	90
	Grand Rapids	1.18	1.17	<5	<5	19	20	90	90
Minn:	Minneapolis	1.22	1.26	<5	<5	26	26	90	90
Miss:	Jackson	1.25	1.20	<5	<5	34	40	60	60
Mo:	Kansas City	1.22	1.20	<5	<5	22	23	60	55
	St. Louis	1.25	1.26	<5	<5	17	20	50	50
Mont:	Helena	1.25	1.29	<5	<5	18	22	95	115
Nebr:	Omaha	1.25	1.22	<5	<5	18,	20	50	55
Nev:	Las Vegas	1.20	1.22	<5	<5	9	6	40	45
N. H:	Manchester	1.16	1.18	<5	<5	24	24	155	155
N. J:	Trenton	1.13	1.12	<5	<5	16	16	80	80
N. Mex:	Albuquerque	1.22	1.28	<5	<5	12	12	45	55
N. Y:	Buffalo	1.11	1.10	<5	<5	17	16	110	120
	New York	1.12	1.09	<5	<5	19	19	105	105
	Syracuse	1.11	1.09	<5	<5	16	17	95	100
N. C:	Charlotte	1.20	1.24	<5	<5	29	30	65	65
N. Dak:	Minot	1.21	1.24	<5	<5	52	61	125	120
Ohio:	Cincinnati	1.16	1.15	<5	<5	17	18	70	70
	Cleveland	1.16	1.16	<5	<5	18	20	95	100
Okla:	Oklahoma City	1.18	1.14	<5	<5	21	20	55	50
Ore:	Portland	1.28	1.29	<5	<5	20	24	100	95
Pa:	Philadelphia	1.16	1.14	<5	<5	17	18	80	80
	Pittsburgh	1.16	1.17	<5	<5	24	24	105	115
P. R:	San Juan	1.14	1.16	<5	<5	12	10	50	50
R. I:	Providence	1.16	1.14	<5	<5	19	16	100	110
S. C:	Charleston	1.20	1.20	<5	<5	30	30	85	100
S. Dak:	Rapid City	1.03	0.82	<5	<5	28	26	135	120
Tenn:	Chattanooga	1.22	1.16	<5	<5	31	30	70	70
	Memphis	1.20	1.14	<5	<5	26	26	45	45
Tex:	Austin	1.15	1.15	<5	<5	9	8	35	20
	Dallas	1.19	1.19	<5	<5	18	22	45	50
Utah:	Salt Lake City	1.30	1.35	<5	<5	25	24	125	130
Vt:	Burlington	1.12	1.11	<5	<5	21	20	120	120
Va:	Norfolk	1.10	1.20	<5	<5	21	21	60	60
Wash:	Seattle	1.26	1.24	<5	<5	23	21	90	90
	Spokane	1.28	1.30	<5	<5	26	29	100	105
W. Va:	Charleston	1.18	1.13	<5	<5	16	18	50	55
Wis:	Milwaukee	1.20	1.23	<5	<5	14	18	100	100
Wyo:	Laramie	1.25	1.24	<5	<5	13	18	65	75
Network average		1.19	·1.18	<5	<5	19.9	20.9	70	82

[a] Results of iodine-131 and barium-140 analyses all below detectable levels.

Table 3. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, November–December 1964, January–April 1965, and April 1964

Strontium-90 (pCi/liter)	Number of stations						
	1964		1965				1964
	Nov	Dec	Jan	Feb	Mar	Apr	Apr
Under 10	6	8	6	3	5	5	4
10–19	31	29	32	31	29	23	12
20–29	19	20	19	22	21	27	26
30–39	6	4	4	5	6	5	12
40–49	1	2	1	2	1	2	2
50–59	0	0	1	0	1	0	2
60–69	0	0	0	0	0	1	3

Table 4. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, November–December 1964, January–April 1965, and April 1964

Cesium-137 (pCi/liter)	Number of stations						
	1964		1965				1964
	Nov	Dec	Jan	Feb	Mar	Apr	Apr
Under 50	15	9	11	8	9	7	2
50–99	41	38	38	38	36	35	12
100–149	4	14	12	15	16	18	23
150–199	2	2	2	2	2	3	17
200–249	1	0	0	0	0	0	7
250–299	0	0	0	0	0	0	2

Slight increases in the April strontium-90 monthly averages were observed for 30 stations while levels at 20 stations decreased slightly from the previous month. The network average strontium-90 concentration for April 1965 was 20.9 pCi/liter. This is only slightly above the March network average of 20.4 pCi/liter but is 23 percent lower than it was a year ago. The ratio of the highest concentration to the average concentration was 2.25 for April 1965 compared to 2.60 for March 1965.

The cesium-137 network average for 63 stations was 82 pCi/liter in April 1965 compared to 81 pCi/liter in March 1965. It is to be noted that the average for April 1965 was 41 percent lower than April 1964. The ratio of the highest concentration to the average concentration was 2.1 for April 1965 compared to 1.9 for April 1964. A continued decrease in radionuclide concentrations in milk should be observed, provided fresh fission debris is not introduced into the atmosphere.

A comparison of the 1965 results through April shows no evidence of the anticipated "spring rise" in strontium-90 or cesium-137 concentration in milk.

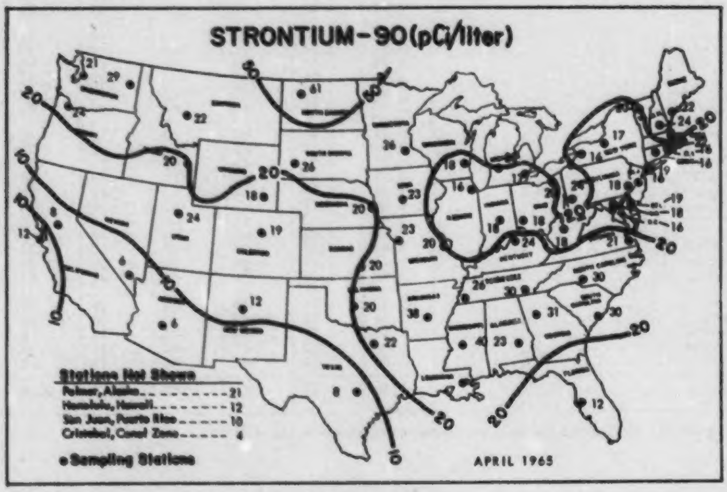

FIGURE 1.— STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

Figure 1. Strontium-90 concentrations in pasteurized milk, April 1965

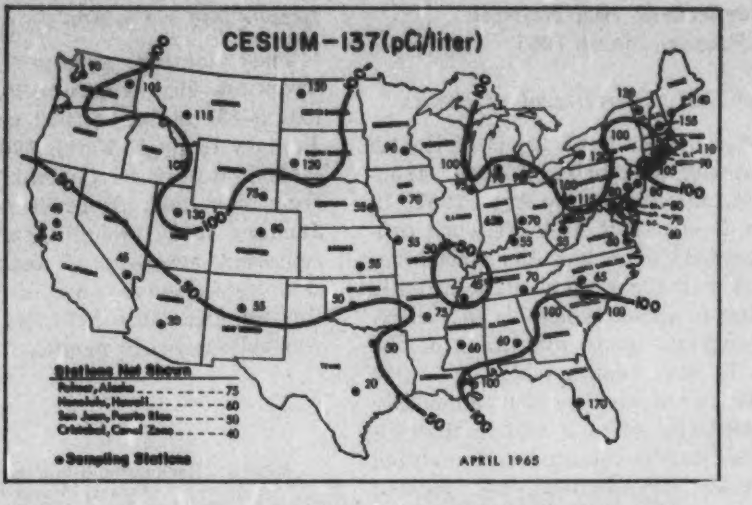
CESIUM-137(pCi/liter)
Stations Not Shown
Palmer, Alaska 75
Honolulu, Hawaii 60
San Juan, Puerto Rico 50
Cristobal, Canal Zone 40
Sampling Stations
APRIL 1965

Figure 2. Cesium-137 concentrations in pasteurized milk, April 1965

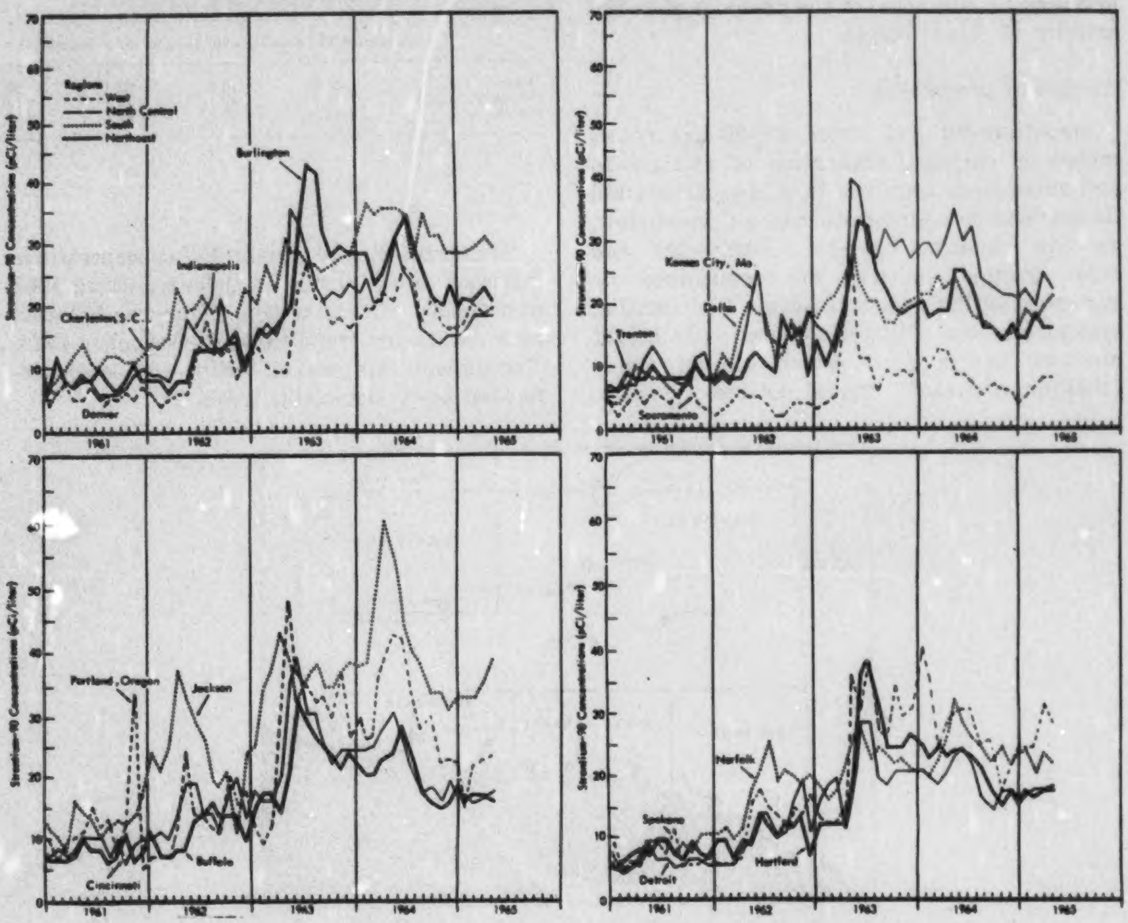

Figure 3. Strontium-90 in pasteurized milk, 1961—April 1965

2. Connecticut Milk Network
January–March 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962 the Connecticut Milk Network program was expanded to include the determination of gamma emitting radionuclides in milk.

The sampling program is flexible in nature. Under this program, up to five areas of the State (figure 4) have been sampled at a frequency up to twice a week. Presently, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are followed as an indication of the presence of radioactivity of recent origin.

Analytical procedures

Strontium–89 and strontium–90 are determined by chemical separation of yttrium–90 and subsequent counting in a low-background Geiger-Mueller counter utilizing a thin-window, gas-flow counting chamber. Iodine–131 and other gamma emitters are determined by gamma scintillation spectroscopy. The counting system consists of a 400-channel pulse height analyzer and a 4- x 4-inch sodium iodide (thallium-activated) crystal detector.

Results and discussion

The monthly average concentrations of strontium–89, strontium–90, cesium–137, and iodine–131 in Connecticut pasteurized milk for January through March 1965 are presented in table 5. Results for Central Connecticut, dating from May 1962, are presented in figure 5. For January 1963 through April 1964, the results represent averages of analyses of composite samples collected once a week; from May through December 1964, one composite sample was collected each month.

Table 5. Radionuclides in Central Connecticut milk, January–March 1965

Month	Radionuclide concentrations, pCi/liter			
	Strontium-89	Strontium-90	Cesium-137	Iodine-131
January	<1	13	80	<10
February	<1	15	70	<10
March	<1	15	30	<10

Strontium–89 and cesium–137 concentrations increased in the spring of 1963, reflecting 1962 atmospheric nuclear testing. This was followed by a decreasing trend through December 1964. Throughout this period, iodine–131 levels remained below detectable levels.

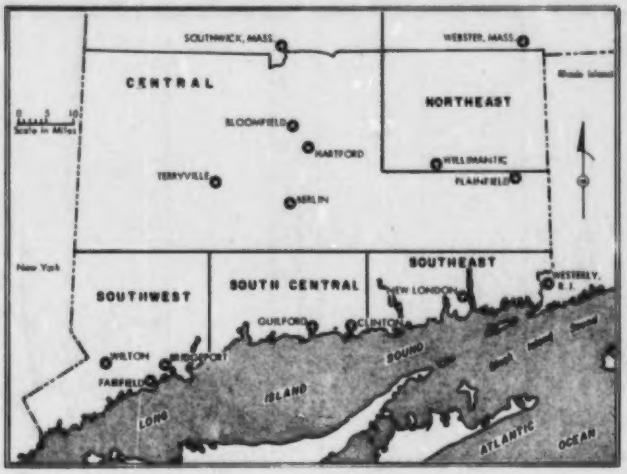
SOUTHWICK, MASS.
WEBSTER, MASS.
Rhode Island
CENTRAL
NORTHEAST
0 5 10
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
PLAINFIELD
TERRYVILLE
BERLIN
New York
SOUTHEAST
WESTERLY, R.I.
SOUTHWEST
SOUTH CENTRAL
NEW LONDON
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
SOUND
ISLAND
LONG
ATLANTIC
OCEAN

Figure 4. Connecticut milk sampling stations

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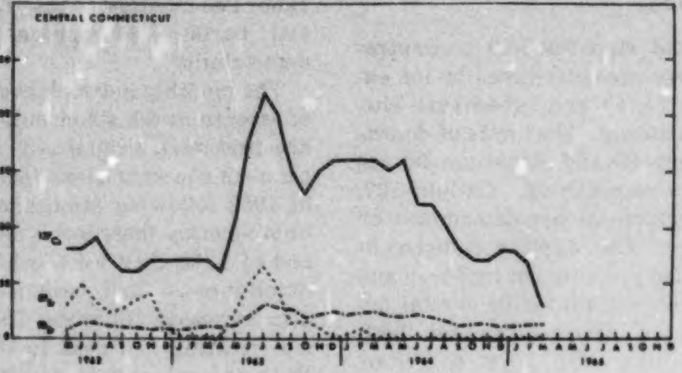

Figure 5. Radionuclides in Connecticut milk

During this period concentrations of strontium-89, strontium-90 and iodine-131 were below the levels for remedial action indicated by the recommendations of the Federal Radiation Council.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
January–December 1963	*September 1964*
January–December 1964	*May 1965*

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3. Indiana Milk Network
January–March 1965

Bureau of Environmental Sanitation, Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. To analyze radionuclide concentrations in Indiana milk effectively, the State was geographically divided into 5 major milksheds: northeast, northwest, central, southeast, and southwest (figure 6). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are routinely analyzed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140. Initially, cesium-137, iodine-131, and barium-140 were analyzed weekly. When iodine-131 concentrations exceeded 100 pCi/liter, the sampling frequency was increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was reduced to once a month for the northeast, southeast, and southwest milksheds. Monthly analyses for strontium-89 and strontium-90 are performed at each station.

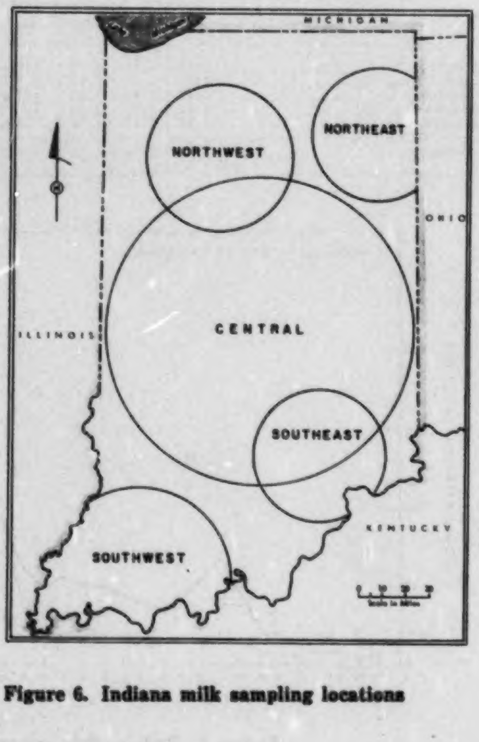

Figure 6. Indiana milk sampling locations

Analytical procedures

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (*4, 5*) and subsequent low-background beta counting. The limits of detectability for strontium-89 and strontium-90 are 5 and 1 pCi/liter, respectively. Cesium-137, iodine-131, and barium-140 are determined by gamma spectroscopy. The counting system consists of a 512-channel pulse height analyzer and a shielded 4 x 4-inch sodium iodide crystal detector. The limit of detectability for both barium-140 and iodine-131 is 5 pCi/liter. Cesium-137 concentrations are subject to a 6 percent error at 100 pCi/liter.

Results and discussion

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 6 for January through March 1965. The monthly concentrations of iodine-131 and barium-140 remained below limits of detectability.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 7. Strontium-89 concentrations increased in the spring of 1962 following atmospheric nuclear testing. Subsequently these levels decreased until by the end of 1963 they were below detectable levels. Strontium-90 and cesium-137 concentrations also increased following 1962 atmospheric nuclear testing to a peak in the summer of 1963. With the subsequent cessation of atmospheric nuclear testing, these levels began a downward trend which has continued to date.

During the period covered, concentrations did not reach levels that required countermeasures based upon health implications. Criteria for such remedial action have been outlined by the Federal Radiation Council (*6*).

Table 6. Radionuclide concentrations in Indiana milk, January–March 1965

Sampling location	Calcium, g/liter			Potassium-40, pCi/liter			Strontium-89 pCi/liter			Strontium-90 pCi/liter			Cesium-137, pCi/liter		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Northeast	1.11	1.15	1.15	1,260	1,290	1,340	0	0	0	13	13	14	70	70	70
Southeast	1.21	1.17	1.17	1,330	1,300	1,320	0	0	0	16	18	17	65	65	65
Central	1.17	1.17	1.15	1,350	1,320	1,320	0	0	0	16	12	13	65	65	70
Southwest	1.17	1.15	1.20	1,410	1,260	1,280	0	0	0	16	18	20	60	60	70
Northwest	1.17	1.17	1.17	1,360	1,330	1,360	0	0	0	19	15	17	70	70	80
Average	1.17	1.16	1.17	1,340	1,300	1,320	0	0	0	16	15	16	65	65	70

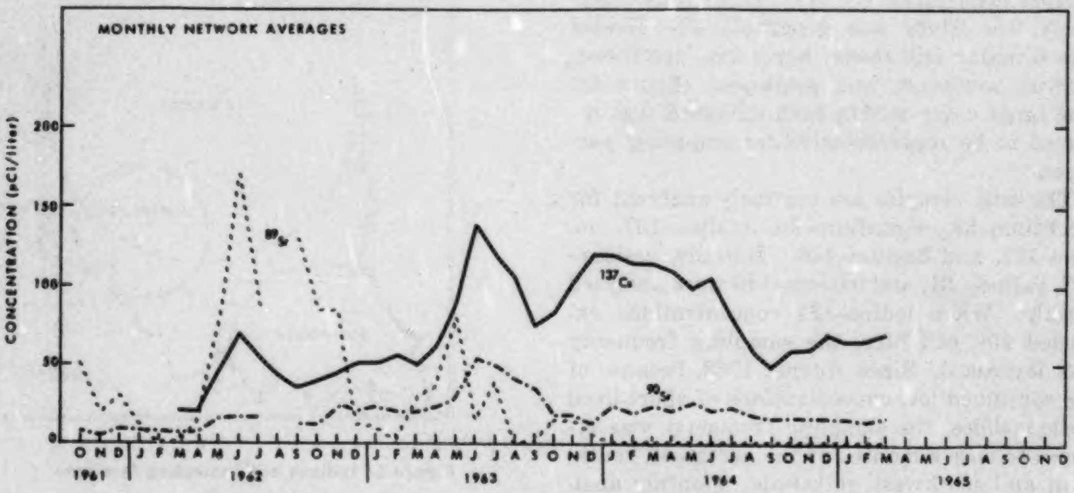

Figure 7. Radionuclide concentrations in Indiana pasteurized milk network

4. Oregon Milk Network
January–March 1965

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored the concentrations of radionuclides in milk throughout Oregon on a continuing basis since the initiation of the milk surveillance program in March 1962. Milk samples are routinely collected at eight major production areas (figure 8), which supply 90 percent of milk distributed in the State.

Half-gallon samples of pasteurized packaged milk are collected monthly from milk-producing plants located in the eight milk-producing areas statewide by Oregon's Department of Agriculture. The Portland milk-producing area samples are collected weekly by the city of Portland. The Portland milk district sample is also analyzed under the USPHS Milk Surveillance Program on a weekly basis, with the results serving as a continuing interlaboratory reference. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or where cesium-137 concentrations exceed 500 pCi/liter. The strontium-90 analyses are usually performed on a bimonthly schedule, but may be done monthly when significant increases are observed.

Analytical procedures

All milk samples are forwarded to and analyzed by the Oregon State Board of Health Environmental Radiation Laboratory. The concentrations of cesium-137, iodine-131, and barium-140 are determined by gamma spectrometry using a 3 x 3-inch scintillation detector with a 512-channel analyzer-computer. The strontium-90 concentrations are determined using a trichloroacetic acid analytical procedure (7), with the counting performed by means of a low-background counting system that includes a 2¼-inch detector.

The minimum detectable limits for determining the concentrations of the radionuclides cesium-137, iodine-131, and barium-140 are 15 pCi/liter; the limit for strontium-90 is 2 pCi/liter. The minimum detectable concentration is defined as the activity which is three times the standard deviation of the observed background activity.

Results and discussion

The cesium-137 concentrations at most of the sampling locations remained relatively stable during this January–March 1965 period, with the exception of a slight increase in March at the Medford and Nyssa sampling locations. The strontium-90 concentrations showed a slight decrease at most of the sampling locations in comparison with the previous period, with the

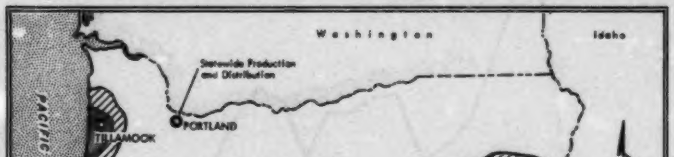

Figure 8. Oregon pasteurized milk network sampling locations showing production and distribution areas

exception of slight increases in the Portland and Baker areas. During this period iodine-131 and barium-140 concentrations remained below the minimum detectable limit of 15 pCi/liter. The results for the January–March 1965 period for all locations appear in table 7.

General trends for the levels of strontium-90 and cesium-137 can be observed from the concentrations representing the monthly network averages presented graphically in figure 9. The peak concentrations experienced in the spring of 1963 have shown a continual decrease, except for seasonal variations. This general trend can be expected to continue with the prolonged cessation of atmospheric nuclear testing.

The radonuclide concentrations in Oregon milk remain low in comparison to the recommendations of the Federal Radiation Council for remedial action based on health implications.

Table 7. Radionuclide concentrations in Oregon milk, January–March 1965

Sampling location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		January	February	March	January	February	March
Baker	M	19	NA	22	75	80	85
Coos Bay	M	20	NA	27	165	150	140
Eugene	M	18	NA	13	85	60	70
Medford	M	14	NA	13	60	130	55
Nyssa	M	17	NA	13	105	70	50
Portland composite	W	15	22	22	88	120	98
Portland local	W	28	NA	33	113	102	108
Redmond	M	16	NA	NA	75	90	65
Tillamook	M	37	NA	28	145	125	130
Average		21		21	101	103	89

Symbol Legend— M—sampled monthly
W—sampled weekly
NS—no sample collected
NA—no analysis performed

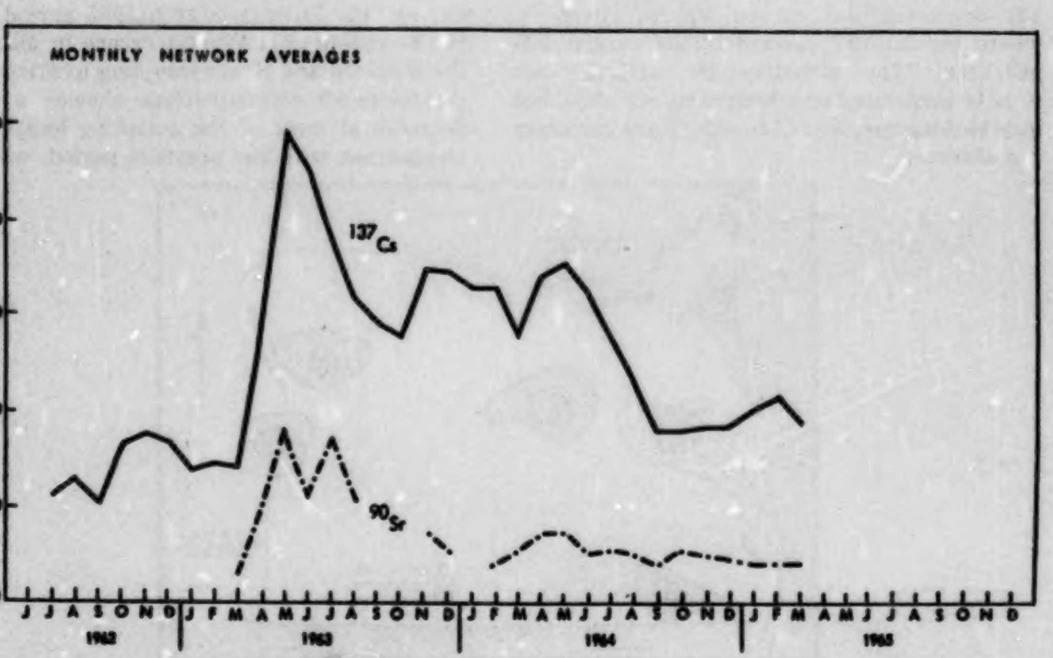

Figure 9. Radionuclides in Oregon milk network

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5. Canadian Milk Network[3]
April 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (see figure 10) can be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet. The prepared sample is then dried under infrared lamps. The residue is ashed in a muffle furnace at 450°C., dissolved in dilute nitric acid, and strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter.

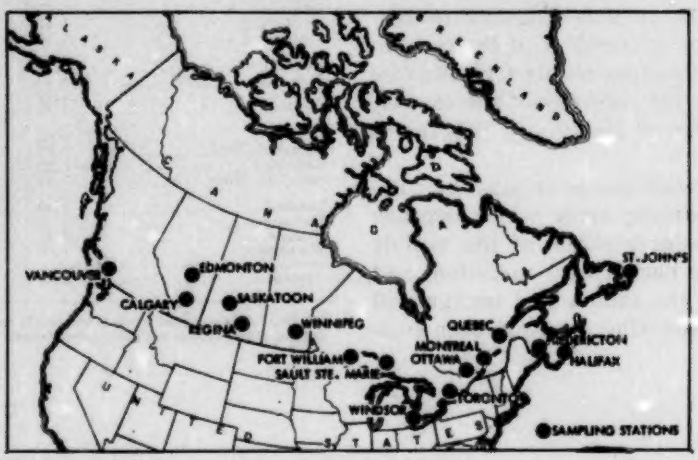

Figure 10. Canadian milk sampling stations

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[3] This report was prepared from information and data in the May 1965 monthly report, "Data from Radiation Protection Programs", Canadian Department of National Health and Welfare, Ottawa, Canada.

Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 8.

Table 8. Total error for various radionuclide concentrations in milk [a]

Nuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 9 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 9. Radionuclides in Canadian whole milk, April 1965 [a]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.17	1.6	23.5	104
Edmonton	1.15	1.7	24.8	113
Ft. William	1.11	1.7	40.1	179
Fredericton	1.15	1.7	34.3	178
Halifax	1.13	1.6	38.9	221
Montreal	1.13	1.7	27.6	156
Ottawa	1.10	1.7	22.7	109
Quebec	1.12	1.6	39.1	221
Regina	1.05	1.6	29.1	104
St. John's, Nfld	1.00	1.5	29.5	171
Saskatoon	1.18	1.7	29.9	110
Sault Ste. Marie	1.01	1.7	37.2	158
Toronto	1.09	1.7	12.6	81
Vancouver	1.15	1.6	32.8	217
Windsor	1.21	1.7	15.8	76
Winnipeg	1.00	1.7	29.0	133
Average	1.11	1.7	29.2	146

[a] Due to insignificant levels of iodine-131 and strontium-89 the reporting of these radionuclides has been discontinued.

6. Pan American Milk Sampling Program April 1965

Pan American Health Organization, and *Public Health Service*

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedures

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963 the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry. Strontium–89, strontium–90 and barium–140 are determined radiochemically (*5*). Analytical errors are discussed in the "Analytical Procedures, Pasteurized Milk Network," page 423.

Data presentation

Table 10 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

Table 10. Stable element and radionuclide concentrations in milk, April 1965

Sampling station	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
	(g/liter)	(g/liter)	(pCi/liter)	(pCi/liter)	(pCi/liter)
Canal Zone: Cristobal	1.23	1.50	<5	4	40
Jamaica: Kingston	1.16	1.64	<5	11	145
Mandeville	[a] NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico: San Juan	1.16	1.60	<5	10	50
Venezuela: Caracas	1.07	1.49	<5	4	25

[a] NS indicates no sample collected during this period.

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(*4*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:676–678 (September 1961).

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, MAY 1964–APRIL 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3,4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 gram daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of the original sources of the radionuclides. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk for the twelve-month periods, April 1964–March 1965 and May 1964–April 1965[a] (pCi/liter)

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Apr 1964–Mar 1965	May 1964–Apr 1965	Apr 1964–Mar 1965	May 1964–Apr 1965	Apr 1964–Mar 1965	May 1964–Apr 1965	Apr 1964–Mar 1965	May 1964–Apr 1965
Ala:	Montgomery	3	3	21	21	0	0	69	66
Alaska:	Palmer	4	3	20	20	0	0	99	93
Ariz:	Phoenix	3	3	5	5	[illegible]	0	26	25
Ark:	Little Rock	3	3	41	40	1	1	93	86
Calif:	Sacramento	3	3	7	7	0	0	35	31
	San Francisco	3	3	9	8	0	0	38	36
C. Z:	Cristobal	3	3	5	5	0	0	48	47
Colo:	Denver	3	3	19	19	0	0	83	81
Conn:	Hartford	3	3	18	18	0	0	112	106
Del:	Wilmington	3	3	22	21	1	1	95	89
D. C:	Washington	3	3	19	19	0	0	67	64
Fla:	Tampa	3	3	15	15	0	0	222	217
Ga:	Atlanta	3	3	29	28	0	0	112	106
Hawaii:	Honolulu	2	3	12	12	0	0	74	72
Idaho:	Idaho Falls	4	3	25	23	0	0	127	117
Ill:	Chicago	3	3	18	18	0	0	94	91
Ind:	Indianapolis	3	3	19	19	1	1	79	75
Iowa:	Des Moines	4	3	24	24	0	0	71	68
Kans:	Wichita	3	3	20	20	0	0	56	54
Ky:	Louisville	3	3	27	26	0	0	64	59
La:	New Orleans	4	4	47	46	0	0	113	105
Maine:	Portland	3	3	27	26	1	1	166	161
Md:	Baltimore	3	3	21	21	0	0	77	72
Mass:	Boston	3	3	28	28	0	0	172	164
Mich:	Detroit	3	3	17	17	2	2	93	90
	Grand Rapids	3	3	20	20	1	1	103	99
Minn:	Minneapolis	5	4	29	28	0	0	110	105
Miss:	Jackson	3	3	39	37	0	0	82	76
Mo:	Kansas City	4	4	25	25	0	0	63	58
	St. Louis	4	3	21	20	0	0	62	58
Mont:	Helena	3	3	21	21	1	1	123	114
Nebr:	Omaha	3	3	23	23	0	0	73	68
Nev:	Las Vegas	3	3	8	8	1	1	57	54
N. H:	Manchester	3	3	27	27	1	1	191	183
N. J:	Trenton	3	3	18	18	1	1	94	89
N. Mex:	Albuquerque	3	2	11	11	1	1	50	47
N. Y:	Buffalo	3	3	19	18	0	0	115	112
	New York	3	3	23	23	1	1	124	117
	Syracuse[b]	3	3	17	17	0	0	108	103
N. C:	Charlotte	3	3	36	35	0	0	93	88
N. Dak:	Minot	8	7	53	53	0	0	137	134
Ohio:	Cincinnati	3	3	20	19	0	0	73	69
	Cleveland	3	3	20	20	0	0	97	94
Okla:	Oklahoma City	3	3	21	21	0	0	57	54
Ore:	Portland	5	4	28	27	0	0	135	128
Pa:	Philadelphia	3	3	19	19	0	0	93	87
	Pittsburgh	3	3	28	27	0	0	122	117
P. R:	San Juan	3	3	12	12	0	0	66	62
R. I:	Providence	3	3	22	21	0	0	129	123
S. C:	Charleston	3	3	31	31	0	0	110	107
S. Dak:	Rapid City	4	4	37	36	0	0	132	130
Tenn:	Chattanooga	3	3	38	36	0	0	92	85
	Memphis	3	3	30	29	0	0	57	54
Tex:	Austin	3	3	8	8	0	0	34	33
	Dallas	3	3	18	18	0	0	48	47
Utah:	Salt Lake City	5	5	24	23	0	0	143	136
Vt:	Burlington	3	3	24	24	2	2	140	133
Va:	Norfolk	3	3	18	18	0	0	77	74
Wash:	Seattle	5	5	27	27	0	0	137	133
	Spokane	5	4	26	26	0	0	121	116
W. Va:	Charleston	3	3	23	22	0	0	58	55
Wis:	Milwaukee	3	3	16	16	1	1	106	101
Wyo:	Laramie	5	4	18	18	0	0	89	86
Network average		3	3	22.4	22.0	0	0	95	91

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <10.

[b] Annual averages were computed on basis of 48 weekly averages.

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EFFECT OF VARIETY ON THE ACCUMULATION OF STRONTIUM-90 IN WHEATS AND THEIR MILLED PRODUCTS

R. A. Anderson and V. F. Pfeifer[1]

Strontium-90 levels in wheats grown in various parts of the United States have been reported for 1963 (*1*) and 1964 (*2*). At the U. S. Department of Agriculture's Northern Regional Research Laboratory, methods are being developed to reduce the radionuclide content of wheats and their milled products. Should a need ever arise for such a process, procedural details would be immediately available.

Information is needed on the effects of variety on uptake of strontium-90 from fallout and by absorption from soil. Rasmusson, Smith, and Myers (*3*) have shown that specific varieties can be selected that minimize uptake by absorption from soil alone. In collecting the 1964 hard red winter (HRW) wheat samples, a series was obtained covering 6 varieties each grown at 5 locations in Kansas, and a series covering a total of 10 varieties grown at 2 locations in Nebraska. These samples permitted: (1) a comparison of differences in strontium-90 uptake by wheat varieties planted in identical soil and grown under identical conditions; (2) a determination as to whether or not the effects of varietal differences extended to other locations in which different sets of growing conditions prevailed; and (3) a comparison of milled products from varieties grown in one location under identical growing conditions, but exhibiting high and low levels of strontium-90 uptake.

Materials

Ten-pound wheat samples representative of the production from large test plots were obtained from five Kansas State University experimental farms. Each farm furnished samples of the following six varieties: Bison, Kaw, Ottawa, Scout, Triumph, and Turkey. The Garden City Station furnished samples from both irrigated and dry-land production. Ten-pound samples were also obtained of 10 different varieties representative of large test plots of the University of Nebraska experimental farms. Five of these were from Lincoln, and five from Alliance.

Procedures

Each lot of wheat was mechanically cleaned in a dockage tester before analysis or milling in order to remove dust and chaff. The wheats were milled in a Buhler experimental flour mill.[2] Strontium-90 was determined by a modification of the method of Harley (*4*). Analyses for protein, ash, and calcium were made by Cereal Laboratory Methods 46–10, 08–01, and 40–20, respectively (*5*).

Results and Discussion

Levels of strontium-90 in the Kansas wheats are given in table 1. Based on the mean values for each variety, uptake of strontium-90 by these wheats was in the following order: Ottawa (highest), Triumph, Kaw, Scout, Bison, and Turkey (lowest). Statistical analysis of these results indicated that uptake by the first three varieties (Ottawa, Triumph, Kaw) was significantly different than by the other three varieties (Scout, Bison, Turkey). As is apparent from table 1, location was a highly significant source of variation.

Strontium-90 in the Nebraska wheats is listed in table 2. The averages for Lincoln and Alliance are 226 and 81 pCi/kg, respec-

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[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

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tively; the large difference is due, at least in part, to the much higher rainfall during May and June in Lincoln. As with the Kansas wheats, Ottawa took up the largest amount of strontium-90 in the five varieties grown at Lincoln, and Bison, the lowest amount. Scout, which was in the lower group of Kansas wheats, was also slightly below the average for the five varieties grown at Alliance.

Results of milling experiments carried out with Ottawa and Turkey HRW wheats, the varieties exhibiting highest and lowest uptake of strontium-90, are given in table 3. Both wheats were grown at Manhattan, Kansas. Each was milled under such conditions that yields of feeds and flours would be similar. The chief differences between the fractions from the two varieties were in the shorts and bran; the flours were about the same. This comparison is shown best in the last column of table 3, which lists the contribution of each fraction to the total strontium-90 present in a kilogram of wheat milled. Nearly equal amounts of strontium-90 were present in the endosperm (flour) fractions, but the outer layers of the Ottawa wheat (bran and shorts) contained nearly 50 percent more than those of the Turkey wheat. These results suggest that the two varieties differ markedly in the amounts of strontium-90 taken up from fallout.

Results reported here indicate that specific wheat varieties can be grown to minimize uptake of strontium-90 from fallout and by absorption from soil. Apparently, considerable differences in uptake from fallout alone are exhibited by different varieties grown under identical conditions. These differences are probably due to slightly different agronomic properties of the wheats, such as heading and ripening, as well as to structural differences in the kernels and glumes. Growing only varieties that take up minimum amounts of strontium-90 from fallout and by absorption from soil, in combination with the removal of the bulk of the contamination by means of effective milling, should ensure foods of the lowest possible contamination under conditions of high-density fallout.

Table 1. Strontium-90 in 1964 hard red winter wheat grown at five locations in Kansas

(pCi/kg calculated on dry basis)[a]

Variety	Location						
	Manhattan	Hays	Garden City		Hutchinson	Newton	Variety mean
			Irrigation	Dry land			
Bison	297	217	159	128	104	197	184
Kaw	289	237	173	179	149	275	217
Ottawa	380	299	230	179	163	239	248
Scout	297	202	190	145	136	187	193
Triumph	334	250	153	193	146	201	233
Turkey	263	188	[b] —	131	131	198	182
Location mean	310	232	181	159	138	220	

[a] Wheat moisture varied from 9.6 to 12.9 percent.
[b] Dash indicates no analysis was done.

Table 2. Strontium-90 in 1964 hard red winter wheat grown at two locations in Nebraska

(calculated on dry basis)[a]

Variety grown in Lincoln	Nitrogen (percent)	Ash (percent)	Calcium (percent)	Strontium-90 (pCi/kg)	Variety grown in Alliance	Nitrogen (percent)	Ash (percent)	Calcium (percent)	Strontium-90 (pCi/kg)
Bison	2.58	1.94	0.050	175	Cheyenne	3.14	1.65	0.047	71
Gage	2.94	1.94	0.055	210	Lancer	2.69	1.57	0.042	90
Omaha	2.95	1.86	0.064	235	Nebred	2.63	1.66	0.046	94
Ottawa	2.79	2.02	0.049	282	Scout	2.79	1.56	0.043	77
Pawnee	2.75	1.80	0.052	226	Warrior	3.17	1.66	0.049	71

[a] Wheat moistures varied from 10.6 to 11.9 percent.

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Table 3. Strontium-90 in milled products from Ottawa and Turkey 1964 wheats grown near Manhattan, Kansas

(analyses on dry basis)

Fraction	Yield (percent)	Nitrogen (percent)	Ash (percent)	Calcium (percent)	Strontium-90 (pCi/kg)	Strontium-90 in fraction (percent of total)	Strontium-90 in fraction (pCi/kg of milled wheat)
Ottawa variety HRW wheat							
Wheat	—	3.21	1.80	0.054	380	—	—
Long patent flour	64.6	3.08	0.47	0.022	44	7.4	29
Clear flour	9.4	3.36	1.02	0.031	80	2.0	8
Shorts	8.5	3.90	4.58	0.132	916	20.0	78
Bran	17.5	3.72	6.15	0.158	1,570	70.6	274
Total	100					100	389
Turkey variety HRW wheat							
Wheat	—	3.17	1.81	0.051	263	—	—
Long patent flour	65.9	2.88	0.53	0.025	40	9.7	27
Clear flour	10.1	3.38	1.13	0.037	79	2.9	8
Shorts	7.5	3.55	4.63	0.117	645	17.7	48
Bran	16.5	2.66	6.18	0.137	1,160	69.7	191
Total	100					100	274

Acknowledgments

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STRONTIUM-90 CONTENT OF HUMAN FOOD AND ANIMAL FEED, 1962-1964

Division of Pharmacology
Food and Drug Administration

This report is a resume of the strontium-90 content of selected human foods and one kind of animal feed for the three harvest years 1962, 1963 and 1964. Because of a considerably smaller number of samples collected in 1964, only a limited number of products can be examined for later geographical and temporal trends. Assessments made for years 1962 and 1963 have previously been reported (*1*).

With the addition of the results from 1964 it is now possible to make a judgment that a downward trend in strontium-90 has started, having begun most probably in the latter part of 1964. The decline is slow, and the indications are that levels of strontium-90 in crops such as wheat, tea, alfalfa and dairy products may maintain sizeable levels for several years to come.

Results

In table 1 are shown the strontium-90 contents of 18 products harvested in the years under study. The data have been tabulated in order of decreasing levels of the nuclide, with no attempt at identification of geographical areas. The same results are shown graphically in figure 1. Without exception, all products exhibited lowest levels of strontium-90 in 1962 and elevation of these levels either in 1963 or 1964. Peak values are about equally distributed in these two years, but in the case of alfalfa and wheat the most decisive peak occurred in 1963. Because alfalfa, wheat, powdered milk, leafy vegetables and root crops constitute a sizeable proportion of the food chain, the declining strontium-90 levels (except cabbage) of these products in 1964 make it likely that the general dietary intake of this nuclide is on the decline.

In table 2 are shown by area the strontium-90 concentrations of 8 products averaged over the years 1962 through 1964. The results show that the highest concentrations of strontium-90 occurred in the Central States (with the exception of cabbage and carrots), next in order (with the exception of spinach) in the Eastern States, and lowest in the Western States.

Table 1. The strontium-90 content of foodstuffs harvested in 1962-1964

Product	1962			1963			1964		
	Strontium-90, pCi/kg		Number of samples	Strontium-90, pCi/kg		Number of samples	Strontium-90, pCi/kg		Number of samples
	Average	Range		Average	Range		Average	Range	
Alfalfa	447	21 —1,700	100	2,190	35 —4,280	118	792	92 —3,340	24
Cabbage	14	0.3—68	127	16	0.4—153	60	32	0.7—145	21
Carrots	7.6	0.3—5	79	17	0.4—64	43	8.7	1.8—25	8
Celery	12	0.7—60	74	19	0.9—118	66	14	5.3—43	8
Cheese	85	18 —281	30	189	12 —689	47	218	14 —783	23
Coffee	16	0.9—90	114	47	1.7—267	41	56	5.0—195	25
Lettuce	17	0.1—178	125	22	1.1—141	127	18	0.7—771	33
Oranges	9.3	1.5—27	13	11	1.9—29	3	21	4.3—38	4
Potatoes	2.3	0.0—6.4	75	11	0.3—157	44	9.5	1.2—21	14
Powdered milk	158	4.8—1,040	33	226	6.2—736	84	207	3 —949	67
Snap beans	20	0.0—80	63	36	2.3—159	81	28	1.0—84	18
Soy beans	75	1.2—693	62	100	2.7—598	75	121	18 —506	9
Spinach	57	5.3—198	36	89	3.1—228	44	56	5.4—162	27
Strawberries	14	0.8—42	21	32	2.7—102	45	41	1.7—129	35
Tea	386	19 —2,290	158	1,010	39 —4,340	55	1,030	42 —7,590	33
Tomatoes	2.6	0.0—9.0	64	6.0	0.0—36	24	2.8	0.6—4.0	4
Tuna fish	0.3	0.0—2.8	35	0.6	0.1—2.5	20	2.3	1.3—5.3	12
Wheat	90	1.4—405	127	260	4 —1,340	123	123	9.7—261	55

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Table 2. Geographic distribution of strontium-90 content in raw agricultural products harvested during 1962, 1963 and 1964

	Western States[1]		Central States[2]		Eastern States[3]	
	Av. conc. ^{90}Sr, pCi/kg	Number of samples	Av. conc. ^{90}Sr, pCi/kg	Number of samples	Av. conc. ^{90}Sr, pCi/kg	Number of samples
Alfalfa	418	68	907	103	704	71
Wheat	70	79	204	190	134	47
Spinach	85	31	96	26	57	40
Lettuce	12	126	38	37	23	122
Strawberries	5.3	19	28	48	36	34
Cabbage	7.2	50	17	75	24	73
Carrots	3.8	50	11	39	19	37
Potatoes	2.0	34	8.0	46	6.8	43

[1] *Western States*
Arizona
California
Colorado
Idaho
Montana
Nevada
New Mexico
Oregon
Utah
Washington
Wyoming

[2] *Central States*
Alabama
Arkansas
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Michigan
Minnesota
Mississippi
Missouri
Nebraska
North Dakota
Ohio
Oklahoma
South Dakota
Tennessee
Texas
Wisconsin

[3] *Eastern States*
Connecticut
Delaware
Florida
Georgia
Maryland
Maine
Massachusetts
New Hampshire
New Jersey
New York
North Carolina
Pennsylvania
Rhode Island
South Carolina
Vermont
Virginia
West Virginia

Table 3 shows the results broken down by year. It can be seen that in the Western and Central States the year 1963 produced the greatest preponderance of higher concentrations of strontium-90, when compared with the 1962 values for that area. In the Eastern States, 5 products (wheat, cabbage, spinach, strawberries and snap beans) reached their highest levels in 1964 compared with 1962 values for that area. It should be emphasized that because of the wide range of values from which averages are calculated, only trends, and not statistical significance at the customary 5 percent level, should be inferred from these results.

Within the frame of reference indicated by the Federal Radiation Council (*2*) no foods reached levels of strontium-90 that would have required protective action such as special processing or substitution to lower the daily intake of this nuclide.

Table 3. Average content of strontium-90 in raw agricultural products by year and area (pCi/kg)

Product	Western States[1]			Central States[2]			Eastern States[3]		
	1962	1963	1964	1962	1963	1964	1962	1963	1964
Alfalfa	186	445	917	532	1,210	1,080	550	973	230
Apples	0.9	4.0	2.6	2.8	11	NS	3.0	9.4	NS
Cabbage	5.0	8.0	18	11	20	16	20	23	76
Carrots	2.3	7.1	3.4	8.5	16	7.1	15	24	21
Celery	4.7	13	7.8	7	20	NS	17	23	21
Lettuce	11	14	12	22	57	42	20	26	16
Peaches	1.7	5.1	NS	9.4	25	NS	5.1	17	NS
Potatoes	1.0	4.4	1.8	2.8	13	10	2.9	13	12
Snap Beans	4.9	11	NS	22	50	16	30	40	50
Spinach	77	86	27	72	114	99	33	71	75
Strawberries	3.0	9.1	6.8	26	35	45	21	35	46
Tomatoes	0.5	2.6	NS	2.2	4.0	NS	4.0	14	2.8
Wheat	30	128	78	107	341	134	93	137	147

[1] [2] [3] States grouped as in table 2.
NS indicates no sample collected.

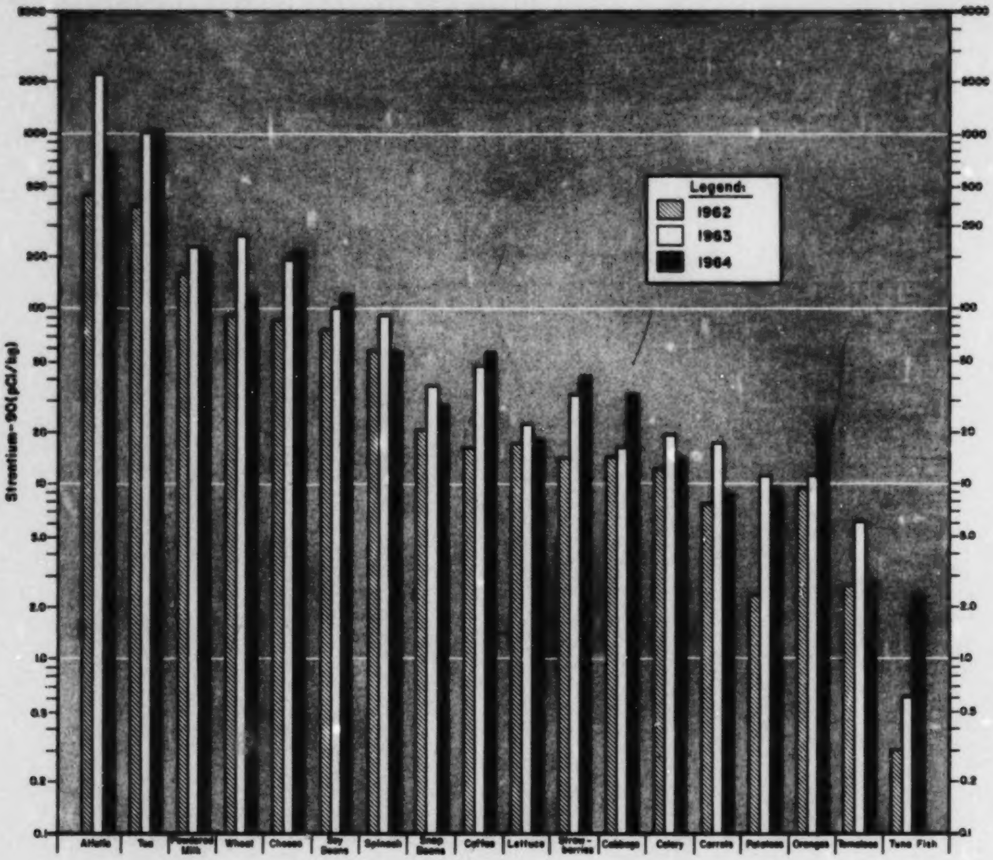

Figure 1. Average strontium-90 contents of foodstuffs, 1962–1964

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, FEBRUARY 1965

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*9*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed for each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was

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questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the most recent results of alpha and beta analysis of U. S. surface waters. The stations on a river are arranged in the table according to their relative locations, the first stations listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957–1962 have been summarized by Weaver *et al* (*10*).

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha and/or beta activity whereas fallout primarily contributes additional beta activity.

Table 1. Radioactivity in raw surface waters, February 1965
(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	13	13	26	4	3	7
Arkansas River:						
Coolidge, Kans	6	118	124	1	40	41
Ponca City, Okla	2	14	16	0	2	2
Atchafalaya River:						
Morgan City, La	173	11	184	62	1	63
Bear River:						
Preston, Idaho	1	18	19	1	3	4
Big Horn River:						
Hardin, Mont	8	20	28	3	7	10
Chena River:						
Fairbanks, Alaska	2	6	8	1	0	1
Clearwater River:						
Lewiston, Idaho	5	7	12	<1	0	<1
Clinch River:						
Clinton, Tenn	0	5	5	0	0	0
Kingston, Tenn	4	31	35	0	0	0
Colorado River:						
Loma, Colo	4	13	17	1	2	3
Page, Ariz	1	34	35	0	9	9
Parker Dam, Calif-Ariz	0	14	14	0	10	10
Columbia River:						
Pasco, Wash	55	260	315	0	1	1
Clatskanie, Ore	19	47	66	1	1	2
Wenatchee, Wash	1	16	17	0	1	1
Connecticut River:						
Enfield Dam, Conn	1	7	8	0	0	0
Coosa River:						
Rome, Ga	4	5	9	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	2	5	7	1	0	1
Delaware River:						
Philadelphia, Pa	3	7	10	0	0	0
Great Lakes:						
Duluth, Minn	0	4	4	0	0	0
Green River:						
Dutch John, Utah	1	25	26	0	3	3
Hudson River:						
Poughkeepsie, N.Y	3	8	11	0	0	0
Kansas River:						
De Soto, Kans	10	18	28	2	2	4
Klamath River:						
Keno, Oreg	4	10	14	0	<1	<1
Maumee River:						
Toledo, Ohio	17	17	34	3	2	5
Mississippi River:						
New Roads, La	21	9	30	6	1	7
New Orleans, La	15	9	24	4	0	4
St. Paul, Minn	1	16	17	0	1	1
Missouri River:						
Williston, N. Dak	7	36	43	0	7	7
Bismarck, N. Dak	2	24	26	0	3	3
St. Joseph, Mo	19	21	40	3	4	7
North Platte River:						
Henry, Nebr	2	68	70	0	56	56
Ohio River:						
Cairo, Ill	22	8	30	9	0	9
Toronto, Ohio	5	6	11	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	5	6	0	1	1
Platte River:						
Plattsmouth, Nebr	24	25	40	4	4	8
Potomac River:						
Washington, D.C	19	5	24	7	0	7
Rainy River:						
Baudette, Minn	1	24	25	0	<1	<1
Red River, North:						
Grand Forks, N. Dak	1	27	28	0	3	3
Red River, South:						
Alexandria, La	57	17	74	20	0	20
Rio Grande:						
El Paso, Tex	4	10	14	0	3	3
Laredo, Tex	4	14	18	0	6	6
San Joaquin River:						
Vernalis, Calif	2	6	8	1	1	2
San Juan River:						
Shiprock, N. Mex	58	16	74	22	3	25
Savannah River:						
Port Wentworth, Ga	4	9	13	<1	0	<1
Snake River:						
Wawawai, Wash	4	8	12	3	1	4
Payette, Idaho	2	10	12	1	2	3
South Platte River:						
Julesburg, Colo	14	87	101	4	53	57
Tennessee River:						
Chattanooga, Tenn	1	8	9	0	0	0
Wabash River:						
New Harmony, Ind	20	53	73	2	1	3
Yellowstone River:						
Sidney, Mont	8	14	22	3	5	8
Minimum	0	4	4	0	0	0
Maximum	173	260	315	62	56	63

* These data are preliminary: reanalysis of some samples may be made and additional analyses not completed at the time of this report may become available. For final data, one should consult the system's annual report.

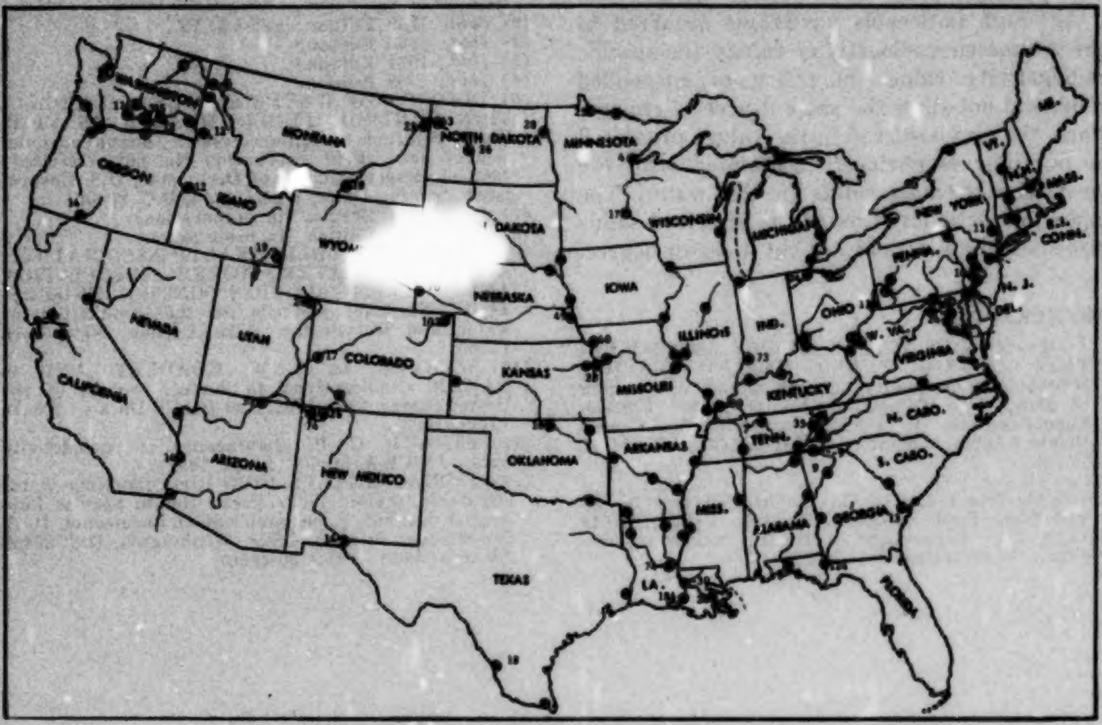
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYO.
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MICHIGAN
IND.
OHIO
KENTUCKY
TENN.
MISS.
ALABAMA
GEORGIA
FLORIDA
S. CARO.
N. CARO.
VIRGINIA
W. VA.
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Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, February 1965

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*11*). The Public Health Service Drinking Water Standards state that when unidentified alpha emitters and strontium-90 do not exceed specific limits of 3 pCi/liter and 10 pCi/liter, respectively, a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*12*).

The rise of radioactivity levels expressed in pCi/liter at a particular station is often presumed to be associated with a corresponding increase in suspended solids. For example, the samples for November 1964, January and February 1965, from the Atchafalaya River at Morgan City, Louisiana, have shown increased alpha and beta activities for suspended solids when compared to results of other recent months. In order to verify and understand the meaning of these results, several steps were taken. Data from the nearest upstream station (Alexandria) was also examined. The results over the five-month period from October 1964 through February 1965 were: average volumetric alpha activity, 46 pCi/liter of suspended solids; and average beta activity, 178 pCi/liter of suspended solids.

A three-month composite of weekly samples collected at Morgan City during the period October through December 1964 was analyzed in triplicate in order to verify the monthly determinations. The average volumetric alpha activity for suspended solids was 53 pCi/liter and the average volumetric beta activity for suspended solids was 147 pCi/liter. The agreement between determinations was excellent, and agreement with the five-month averages at Morgan City and Alexandria was reasonable.

Although noticeable variations occurred in the volumetric radioactivity values, the specific radioactivity values in pCi/g of suspended solids did not show the same degree of change. Thus, the rise observed in the values presented in pCi/liter is obviously associated with the level of suspended solids in the water. The alpha and beta activities of the dissolved solids also show the same pattern but in lesser degree.

REFERENCES

(*1*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[1]

(*4*) *Ibid.*, 1961 Edition.[1]

(*5*) *Ibid.*, 1962 Edition.[1]

(*6*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS publication No. 663, (Revised) 1963 ed. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) *Ibid.*, 1964 Edition (in preparation).

(*8*) *Ibid.*, 1965 Edition (in preparation).

(*9*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition, New York (1960).

(*10*) WEAVER, L., A. W. HOADLEY, AND S. BAKER. Radioactivity in surface waters of the United States, 1957–1962. Rad Health Data 4: 306–16 (June 1963).

(*11*) STRAUB, C. P. Significance of radioactivity data. JAWWA 53:704 (June 1961).

(*12*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 (March 1963). Price 30 cents.

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[1] Single free copies of this publication may be obtained from Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES,[1] JULY-DECEMBER 1964

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, six surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at each station. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

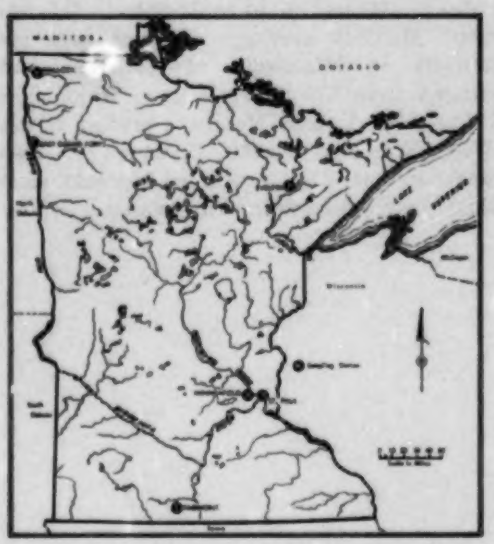

Figure 1. Minnesota surface water sampling locations

Table 1 shows a summary of the monthly average gross beta activity in Minnesota municipal water supplies from July–December 1964. The minimum reported level corresponding to an error of one standard deviation is 15 pCi/liter at present. In averaging, the value 7 pCi/liter is used for samples having less than the minimum detectable value.

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[1] Data and information from "Survey of Environmental Radioactivity, July–December 1964." State of Minnesota Department of Public Health, University Campus, Minneapolis 14, Minnesota 55440, COO-651-10.

Table 1. Total beta concentrations in Minnesota raw and treated water supplies, July–December 1964

[Monthly average concentrations in pCi/liter]

Town and water source	Type of water	July	Aug	Sept	Oct	Nov	Dec
East Grand Forks, Red Lake River	Raw	54	64	27	28	32	29
	Treated	25	17	11	7	17	19
Eveleth, St. Mary's Lake	Raw	21	20	28	19	32	25
	Treated	24	23	6	14	16	21
Fairmount, Budd Lake	Raw	14	22	12	25	28	19
	Treated	9	13	27	11	7	16
Hallock, Two Rivers South Fork	Raw	64	43	46	37	46	40
	Treated	29	10	9	11	14	23
Minneapolis Tap Water	Raw	* NS	NS	NS	NS	NS	NS
	Treated	7	7	7	10	7	15
St. Paul, Vadnais Chain of Lakes	Raw	16	23	16	28	24	21
	Treated	7	12	9	7	13	14

* NS indicates no samples collected.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Differences in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 64 pCi/liter, which is well below the Public Health Service Drinking Water Standard of 1000 pCi/liter (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (March 1963). Price 30 cents.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
October 1957–August 1959	*April 1960*
August 1959–April 1962	*August 1962*
April 1962–November 1962	*April 1963*
December 1962–June 1963	*November 1963*
July–December 1963	*June 1964*
January–June 1964	*January 1965*

Section IV—Other Data

MEASUREMENT OF IODINE-131 IN BOVINE THYROIDS

Kenneth H. Falter and *George Murray*[1]

The Division of Radiological Health, U.S. Public Health Service, in cooperation with the Meat Inspection Division, U.S. Department of Agriculture, has been collecting and analyzing bovine thyroids for iodine–131 in order to supplement existing environmental radiation surveillance data. The study was begun on a pilot basis in September 1962, and the program was operative from January 1963 to January 1964. The program is described in detail in a previous report (*1*), which also presented data from 760 samples collected and analyzed between January 20 and June 29, 1963.

Between June 30, 1963, and January 3, 1964, when this phase of the program was temporarily suspended, a total of 1445 thyroid specimens were collected and analyzed for iodine–131 activity. Of these, 875 were from cows that were lactating at the time of slaughter, and 570 were from nonlactating cows. The counties from which samples were received are indicated in figure 1. The counties in black are in milkshed areas; those lightly shaded lie outside milkshed areas. The number of samples collected, their classification in terms of lactation status, and identification as to whether they were from a milkshed or not, are shown in table 1.

Results

Of the 1445 samples collected and analyzed, only 30 individual samples had iodine–131 levels exceeding 3.5 picocuries per gram. The significance of this level will be discussed below. Three weekly averages exhibiting concentrations above 3.5 picocuries per gram were observed in this study. These weekly averages and the 30 individual sample values are listed in table 2. The weekly average is the arithmetic mean for the given number of thyroids from cows slaughtered that week. The two-sigma or 95 percent counting error (95 percent C.E.) is an indication of the inherent statistical variation associated with all measurements of radionuclide concentrations. The concentration ± 95 percent C.E. is the range within which the true concentration is expected to lie 95 percent of the time.

Prior to November 1963, samples were counted for 100 minutes on either a single-channel or dual-channel gamma spectrometer, using a scintillation well detector containing a three-inch diameter NaI(Tl) crystal (*1*). Beginning in November 1963, samples were screened for 10 minutes on the dual-channel analyzer. If the net count rate was less than 3.5 counts per minute (cpm), this activity was considered to be due to fluctuation in the background, and the specimen activity was taken as nondetectable.

Weekly averages for those milksheds providing a continuing supply of specimens are plotted in figures 2–5. The solid lines connect the data points for lactating cows, and the dotted lines connect the data points for nonlactating cows.

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[1] Mr. Falter was Project Officer, Bovine Thyroid Study, Research Branch, and is currently with the Training Branch, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. Dr. Murray is Staff Officer for Procedures and Requirements, Consumer Marketing Service, Meat Inspection Division, U.S. Department of Agriculture, Washington, D.C.

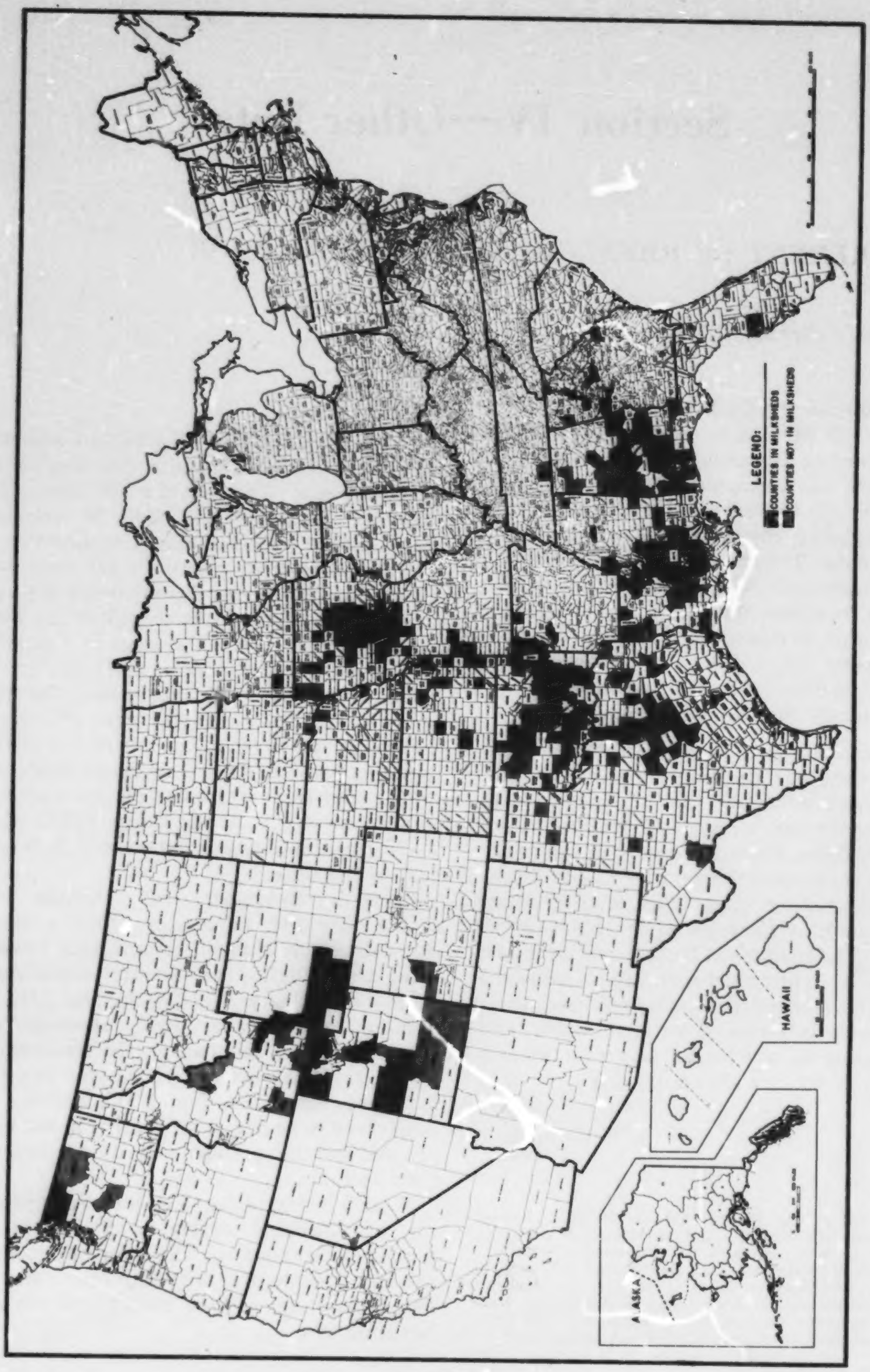
LEGEND:
COUNTIES IN MILKSHEDS
COUNTIES NOT IN MILKSHEDS
HAWAII
ALASKA

Figure 1. Sample collection areas in the bovine thyroid collection program

Discussion of data

During the second half of the study, it was found that a long-lived radionuclide was affecting the assay of iodine-131 in some of the specimens. Nine specimens exhibiting little radioactive decay were investigated more closely, and the contamination was identified as radium-226. This phenomenon will be discussed more fully in a forthcoming report (*2*). Van Middlesworth (*3*) has also reported this type of contamination in samples of cattle thyroid glands.

Interpretation of the data is complicated by the presence of this long-lived radionuclide. The amount of radium-226 found in the nine specimens, if mistakenly taken to be iodine-131, would correspond to 8 pCi ^{131}I/g thyroid. A pooled sample consisting of all thyroids previously analyzed for iodine-131 was ashed and analyzed for radium-226 and found to contain about one-fifth the activity of the nine samples previously mentioned. This amount of radium-226, if considered to be iodine-131, would correspond to approximately 3.5 pCi ^{131}I/g thyroid.

Based on these two figures, 8 and 3.5 pCi ^{131}I/g thyroid, the data may be interpreted as follows: levels above 8 pCi ^{131}I/g thyroid may be interpreted as due to some combination of iodine-131 and radium-226 which could be misinterpreted as iodine-131. However, the maximum contribution of radium-226 is 8 pCi/g. Values below 3.5 pCi ^{131}I/g thyroid can be considered, on the average, as radium-226 contamination alone. Values between 3.5 and 8 pCi ^{131}I/g thyroid are subject to question as to how much of this activity is actually iodine-131 and how much is the radium-226 contamination. Consequently, we have defined 8 pCi ^{131}I/g thyroid as the lower level of reliability and have presented all samples with activity above 3.5 pCi ^{131}I/g.

Based on a calculation (*4*) that milk levels (pCi ^{131}I/liter) are, on the average, about 8 percent of the thyroid levels (pCi ^{131}I/g), then the lower limit of reliability for thyroids is equivalent to about 0.6 pCi ^{131}I/liter of milk. Thus, even allowing for small amounts of radium contamination, bovine thyroids proved more sensitive than fluid milk (by greater than one order of magnitude) as an indicator of environmental intrusions of iodine-131.

Table 1. Distribution of origin of bovine thyroids

State	Milkshed	Condition of cow	
		Lactating	Nonlactating
Ala	Montgomery	104	104
	Nonmilkshed	36	43
Ark	Little Rock	13	
	Nonmilkshed	1	
Colo	Nonmilkshed		2
Fla	Tampa		1
	Nonmilkshed	1	
Ga	Atlanta	5	6
	Nonmilkshed	1	
Idaho	Idaho Falls	1	
	Nonmilkshed	1	2
Iowa	Des Moines	113	116
	Nonmilkshed	37	23
Kans	Nonmilkshed	1	
La	New Orleans	34	9
	Nonmilkshed	114	55
Miss	Jackson	43	16
	Nonmilkshed	16	6
Mo	Kansas City	92	66
	St. Louis	24	14
	Nonmilkshed		2
Mont	Nonmilkshed	3	
Nebr	Nonmilkshed	1	
Okla	Oklahoma City	119	44
	Nonmilkshed	72	21
S. Dak	Nonmilkshed		1
Tenn	Memphis	4	
	Nonmilkshed		8
Tex	Austin	4	1
	Dallas	16	1
	Nonmilkshed	12	5
Utah	Salt Lake City	3	15
	Nonmilkshed	3	9
Wash	Seattle	1	
Total		875	570

Table 2. Values above the lower limit of reliability

State	Milkshed	Week 1963	Condition of cows	Average pCi ^{131}I/g	95% C.E.[a]
Weekly averages					
Ala:	Montgomery	9/15	[b]Lactating (4)	3.7	2.2
		10/20	Lactating (4)	4.3	1.0
Iowa:	Des Moines	10/27	Nonlactating (2)	4.1	0.9
Individual values					
Ala:	Montgomery	8/4	Lactating	6.3	3.6
		8/11	Nonlactating	3.6	2.2
		8/18	Nonlactating	3.5	2.5
		9/1	Nonlactating	4.6	2.6
		9/15	Lactating	9.6	8.5
		9/22	Lactating	4.2	3.6
		9/22	Nonlactating	4.6	1.9
		10/20	Lactating	5.0	1.8
		10/20	Lactating	4.4	1.5
		10/20	Lactating	4.3	2.8
		10/20	Lactating	3.7	1.2
		10/20	Nonlactating	4.8	1.7
	Nonmilkshed	8/25	Lactating	3.6	2.0
Iowa:	Des Moines	7/21	Nonlactating	3.7	2.5
		9/1	Lactating	4.3	1.5
		9/15	Lactating	5.2	1.7
		10/13	Nonlactating	9.4	2.5
		10/13	Nonlactating	5.2	3.0
		10/20	Nonlactating	4.6	2.4
		10/20	Nonlactating	3.5	2.2
		10/27	Lactating	8.4	1.5
		10/27	Lactating	4.6	1.5
		10/27	Nonlactating	4.5	1.0
La:	New Orleans	9/29	Nonlactating	5.7	1.9
Miss:	Nonmilkshed	10/27	Lactating	3.7	0.9
Mo:	Kansas City	8/4	Nonlactating	6.6	1.7
		9/15	Lactating	4.3	1.4
		9/15	Nonlactating	4.4	1.6
Okla:	Oklahoma City	7/21	Lactating	3.9	1.4
Utah:	Salt Lake City	10/27	Nonlactating	4.6	1.4

[a] Two-sigma or 95 percent counting error.

[b] Figures in parentheses represent number of specimens.

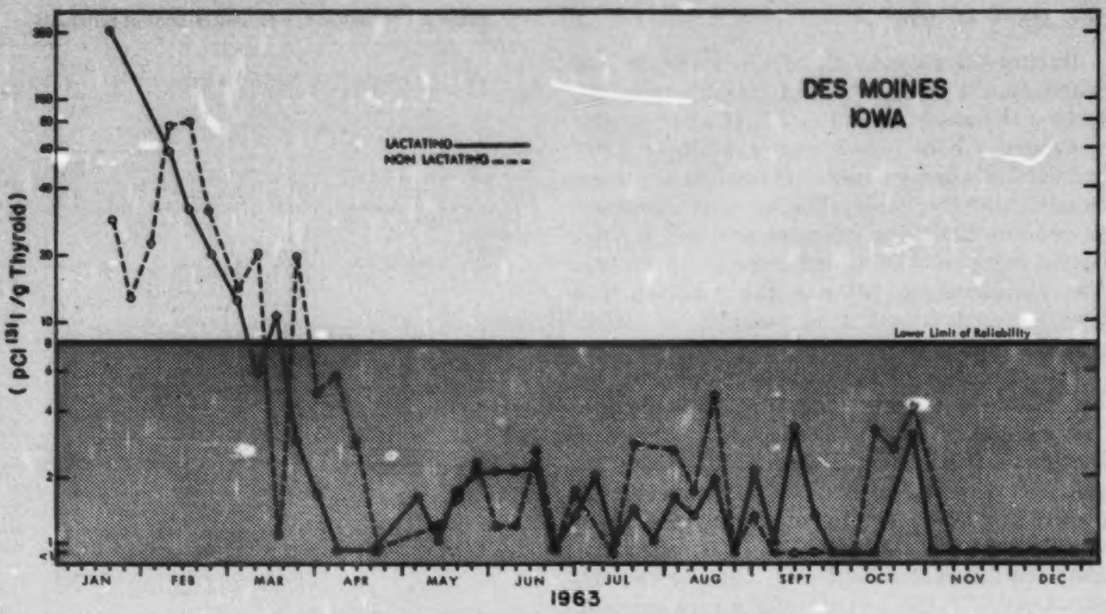

Figure 2. Weekly averages for Des Moines milkshed

Moreover, the use of a multichannel analyzer, or suitable method of gamma spectrum analysis using a single- or dual-channel analyzer, would readily identify any contribution of radium-226 to counts in the iodine-131 peak region. By this means, the lower level of reliability of the system could be reduced to about 1 to 2 pCi ^{131}I/g of thyroid.

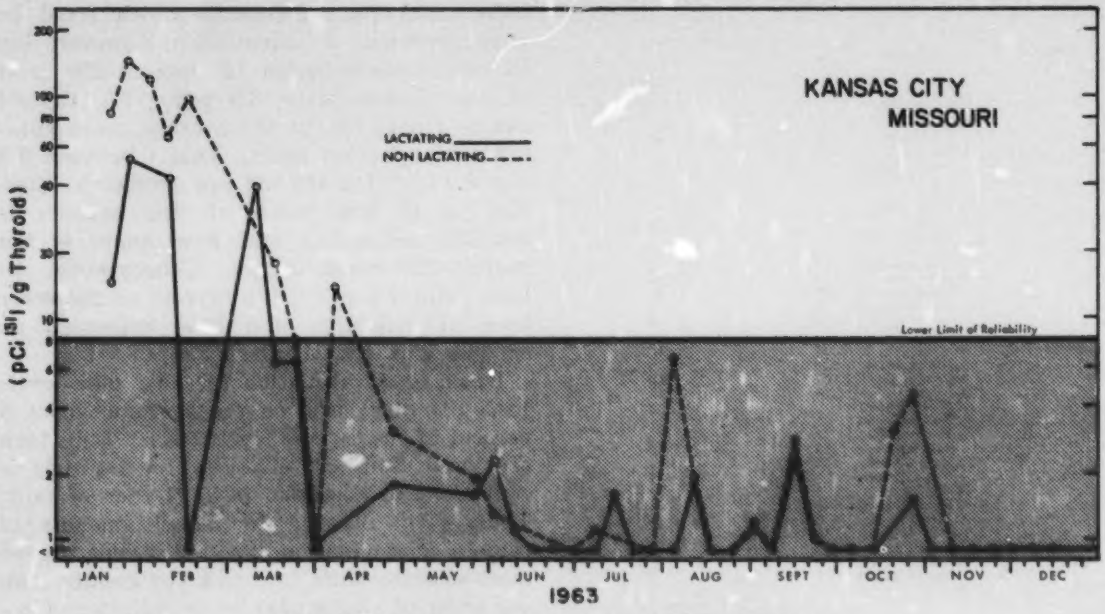

Figure 3. Weekly averages for Kansas City milkshed

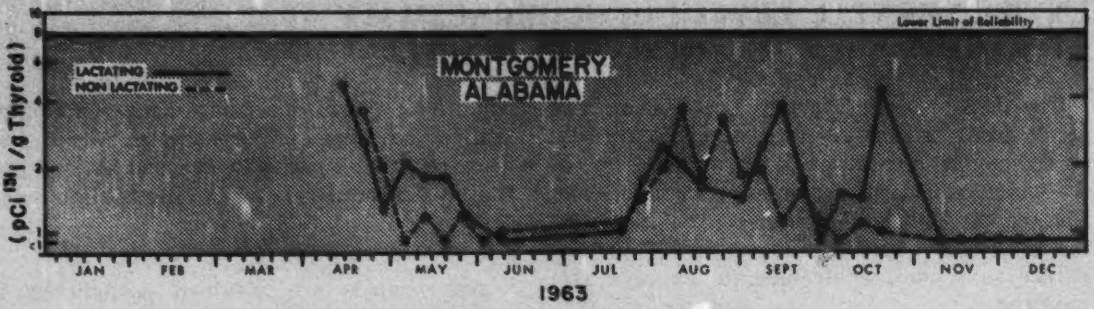

Figure 4. Weekly averages for Montgomery milkshed

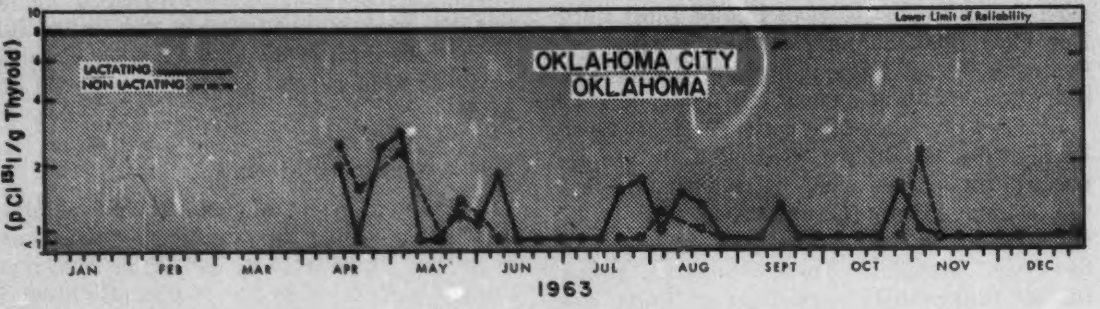

Figure 5. Weekly averages for Oklahoma City milkshed

Summary of study—
January 1963 to January 1964

Inasmuch as the collection of bovine thyroids was temporarily suspended in January 1964, the following section is presented to summarize the data obtained up to that time.

A total of 2205 thyroid specimens were collected and analyzed for iodine–131 from January 1963 to January 1964. These specimens have been categorized in table 3.

Milkshed averages ranged from a high of 202 pCi/g in the Des Moines milkshed in January 1963 down to the limit of reliability in April 1963.

Table 3. Summary of thyroid specimens

Specimen category	Milkshed	Nonmilkshed	Total
Lactating	872 (40%)	430 (19%)	1,302 (59%)
Nonlactating	623 (28%)	280 (13%)	903 (41%)
Total	1,495 (68%)	710 (32%)	2,205 (100%)

Conclusions

The problem of radium–226 contamination must be considered in any future bovine thyroid studies. The use of a suitable method of gamma spectrum analysis will identify any contribution of radium–226 to counts in the iodine–131 peak region. This will reduce the lower level of reliability of the system to 1 to 2 pCi ^{131}I/g thyriod. Bovine thyroids are more sensitive than fluid milk (by greater than one order of magnitude) as an indicator of environmental intrusions of iodine–131.

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(*1*) FALTER, K. H. *et al.* In vitro measurement of iodine–131 in bovine thyroids, Rad Health Data 4: 527–534 (October 1963).

(*2*) FALTER, K. H. Radium–226 in bovine thyroids (in preparation).

(*3*) VAN MIDDLESWORTH, L. Long-life radioactivity in occasional thyroids. Nature 203:199–200 (July 11, 1964).

(*4*) FISH, B. R. *et al.* The merits of cattle thyroid analysis for the detection of I–131 in the environment. App Health Phys Ann Report ORNL–3490: 72–73 (1962).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Pinellas Peninsula Plant, Savannah River Plant, and Shippingport Atomic Power Station.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentration limits, are applicable to effluents released from AEC installations.

1. Pinellas Peninsula Plant[2]
July–December, 1964

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 1, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the environmental levels of radioactive contamination associated with Plant effluents. These measurements serve as an index of the effectiveness of the Plant's contamination control measures. Environmental monitoring includes sampling of a single combined sewer effluent, milk from four local dairy farms, and air and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples, which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the 28 samples collected during the sampling period revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pCi/m^3 for tritium gas and 5,000 pCi/m^3 for tritium oxide.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. There were no detectable concentrations of tritum oxide (> 90,000 pCi/liter) in the 127 samples analyzed during the sampling period.[3]

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (> 90,000 pCi/liter) in the 49 surface water samples analyzed during the sampling period.

Milk sampling results

Sixteen samples of raw milk were collected from farms within a 3-mile radius of the Plant. These samples were analyzed by the Florida State Board of Health during 1964. No detectable concentrations (> 90,000 pCi/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1960–1961	*July 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
January–June 1964	*February 1965*

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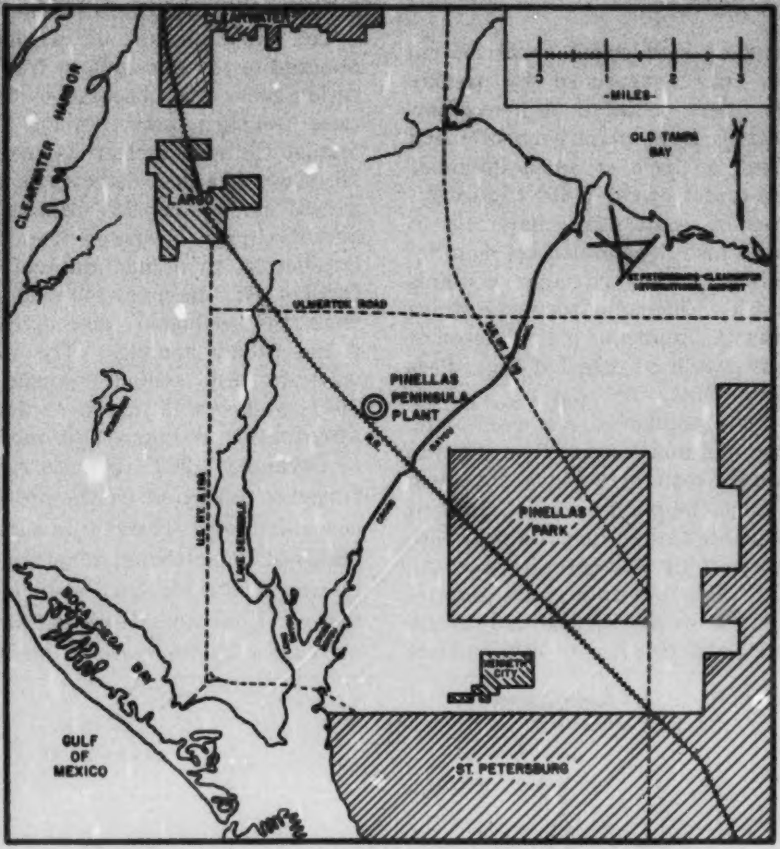
[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Environmental Monitoring, July 1 through December 31, 1964," General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Fla.

[3] Expressions in parentheses indicate limits of detectability in the respective environmental samples.


CLEARWATER
CLEARWATER HARBOR
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ULMERTON ROAD
PINELLAS PENINSULA PLANT
R.R.
U.S. RT. 19
LAKE SEMINOLE
PINELLAS PARK
BOCA CIEGA BAY
KENNETH CITY
GULF OF MEXICO
ST. PETERSBURG

Figure 1. Location of the Pinellas Peninsula Plant

2. Savannah River Plant
July–December 1964[4]

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a fuel preparation area, four reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The du Pont Health Physics Section has maintained a continuous monitoring program since 1951 (prior to plant startup) to determine the concentrations of radioactive materials in a 1200-square mile area outside the plant. This surveillance determines the magnitude and character of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the Maximum Permissible Concentrations (MPC) in the AEC Manual (see footnote 1).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Maximum and minimum values given are for individual samples collected during the reporting period.

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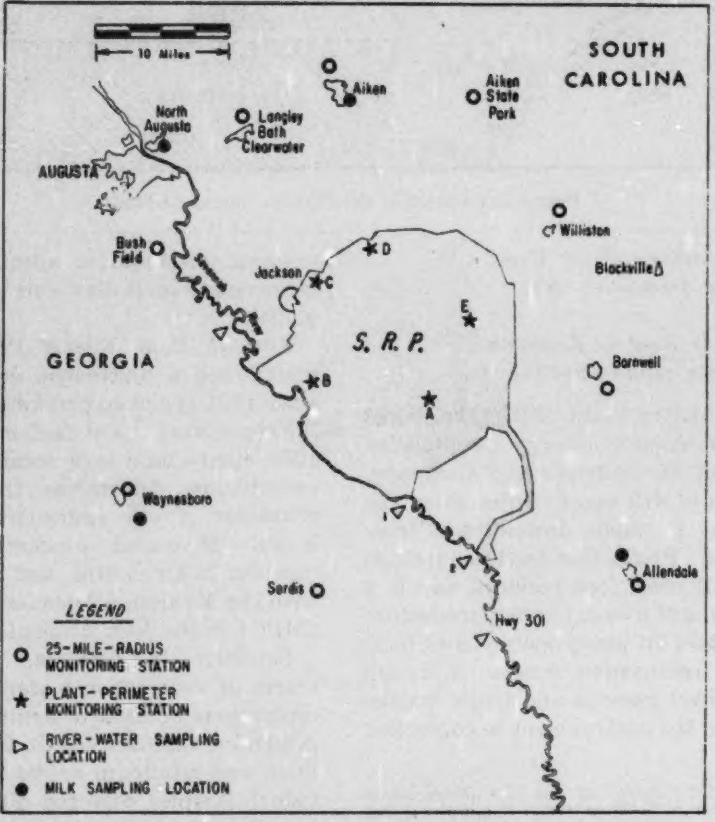
[4] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July through December 1964." (DPSPU 65-30-1).

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at 5 monitoring stations located on the plant perimeter and 9 stations around a circle of about 25 miles radius from the center of the plant (figure 2). Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that the effect of SRP operations is negligible; they are reference points for determining background activity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

The small amount of radioactive materials released to the atmosphere from the fuel separation areas was obscured by fallout from nuclear weapons tests. Fallout from the Communist Chinese nuclear detonation of October 16, 1964, was first detected in the atmosphere at SRP on October 22. Concentrations of beta activity in air increased from 0.09 pCi/m^3 on October 21 to a maximum of 2.4 pCi/m^3 on October 27. Barium–140 and lanthanum–140 were the principal short-lived radionuclides found in air samples. The influence of the weapons tests which resumed in September 1961 is shown in figure 4. Even though the atmospheric weapons test moratorium began in December 1962, airborne radioactivity continued to remain above the pre-September 1961 concentrations. The rise in early 1964 was the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere. Communist Chinese weapons test fallout caused the increase in late 1964.


10 Miles
SOUTH CAROLINA
Aiken
Aiken State Park
North Augusta
Langley
Bath
Clearwater
AUGUSTA
Williston
Bush Field
Jackson
Blackville
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D
C
E
B
A
GEORGIA
Barnwell
Waynesboro
1
2
Allendale
Sardis
Hwy 301
LEGEND
○ 25-MILE-RADIUS MONITORING STATION
★ PLANT-PERIMETER MONITORING STATION
▷ RIVER-WATER SAMPLING LOCATION
● MILK SAMPLING LOCATION

Figure 2. Environmental sampling locations, Savannah River Plant

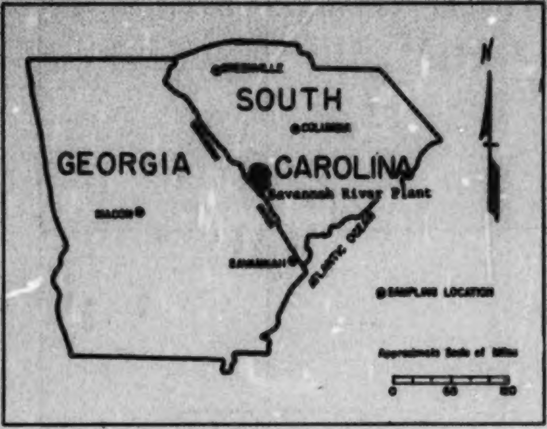

Figure 3. Distant air monitoring stations, Savannah River Plant

Radioactivity in air, determined from filter analyses, is shown in table 1. The July–December 1964 concentrations of beta activity (0.35 pCi/m³) and alpha activity (0.0007 pCi/m³) in air were 0.4 percent and 1.8 percent of their respective MPC's. Iodine-131 concentrations in air samples were less than 0.02 pCi/m³, the lower detection limit. The relative abundance of airborne radionuclides since January 1963 is shown in figure 5. The diminishing activity is proportional to the areas of the circles which show average activity for each six-month period. Aging of the fallout is seen from increasing percentages of the longer-lived radionuclides strontium-90, cesium-137, and ruthenium-106, while fresh nuclear weapons test fallout is indicated by the presence of ruthenium-103 and barium-lanthanum-140 during July–December 1964. Tritium oxide concentrations in air were measured continuously at the plant perimeter and at the 25-mile stations; the average concentration did not exceed 2 percent of the MPC.

Table 1. Radioactivity in air, pCi/m³

(Filter analyses)

	Plant-perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Av	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Av
Alpha Emitters in Air [a] (multiply by 10^{-3})																
Max	2.4	1.8	1.0	1.6	1.2		1.3	1.6	1.2	2.0	2.0	2.1	1.3	1.2	4.[illegible]	
Min	[b]	0.3														
Av	0.6	0.7	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.7	0.8	0.7	0.6	0.9	0.7
Nonvolatile Beta Emitters in Air, [c]																
Max	1.71	1.40	1.34	1.73	1.73		1.70	1.20	2.03	1.40	1.12	1.04	1.46	1.66	1.34	
Min	0.07	0.05	0.09	0.07	0.07		0.07	0.08	0.08	0.09	0.06	0.06	0.09	0.01	0.06	
Av	0.38	0.35	0.36	0.39	0.36	0.36	0.42	0.34	0.38	0.36	0.28	0.35	0.35	0.34	0.34	0.35
Specific Radionuclides in Air (Averages),																
^{137}Cs	0.02	0.03	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
^{144}Ce	.14	.13	.12	.12	.12	.13	.13	.13	.12	.13	.12	.10	.12	.10	.13	.12
^{103}Ru	.04	.03	.04	.03	.04	.04	.04	.03	.03	.03	.04	.02	.04	.02	.04	.03
^{106}Ru	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
^{95}Zr-Nb	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
^{54}Mn	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
^{140}Ba-La	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

	Distant air-monitoring locations										
	Columbia, S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga.	Av		Columbia, S.C.	Greenville, S.C.	Macon, Ga.	Savannah, Ga.	Av
Alpha Emitters in Air [a] (multiply 10^{-3})						Nonvolatile Beta Emitters in Air [c]					
Max	2.5	2.8	2.2	1.4			1.14	1.26	1.36	1.22	
Min							0.06	0.08	0.08	0.11	
Av	0.8	1.0	0.8	0.7	0.8		0.33	0.36	0.34	0.34	0.34
Specific Radionuclides in Air (Averages),											
^{137}Cs	0.03	0.03	0.02	0.03							
^{144}Ce	.12	.15	.12	.18							
^{103}Ru	.02	.05	.03	.09							
^{106}Ru	.01	.01	.01	.01							
^{95}Zr-Nb	.02	.02	.02	.02							
^{54}Mn	.01	.01	.01	.01							
^{140}Ba-La	0.07	0.07	0.07	0.07							

[a] MPC = 40; Sensitivity of analysis 0.3.
[b] Blank indicates levels below sensitivity of analysis.
[c] MPC = 100; sensitivity of analysis, 0.006.

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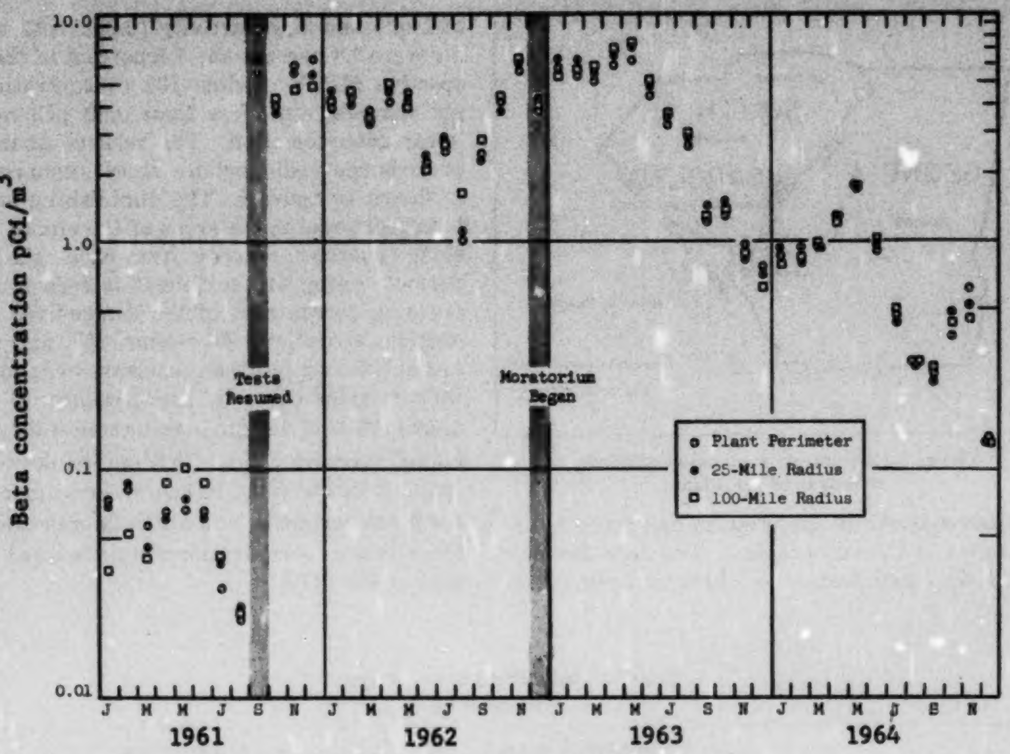


Figure 4. Effects of weapons tests

Deposition of radioactive materials during the second half of 1964 totaled 69 mCi/sq mile at plant perimeter locations and 65 mCi/sq mile at the 25-mile radius locations; comparable values for the first half of 1964 were 366 mCi/sq mile and 343 mCi/sq mile, respectively. Deposition at each sampling location is recorded in table 2.

Vegetation

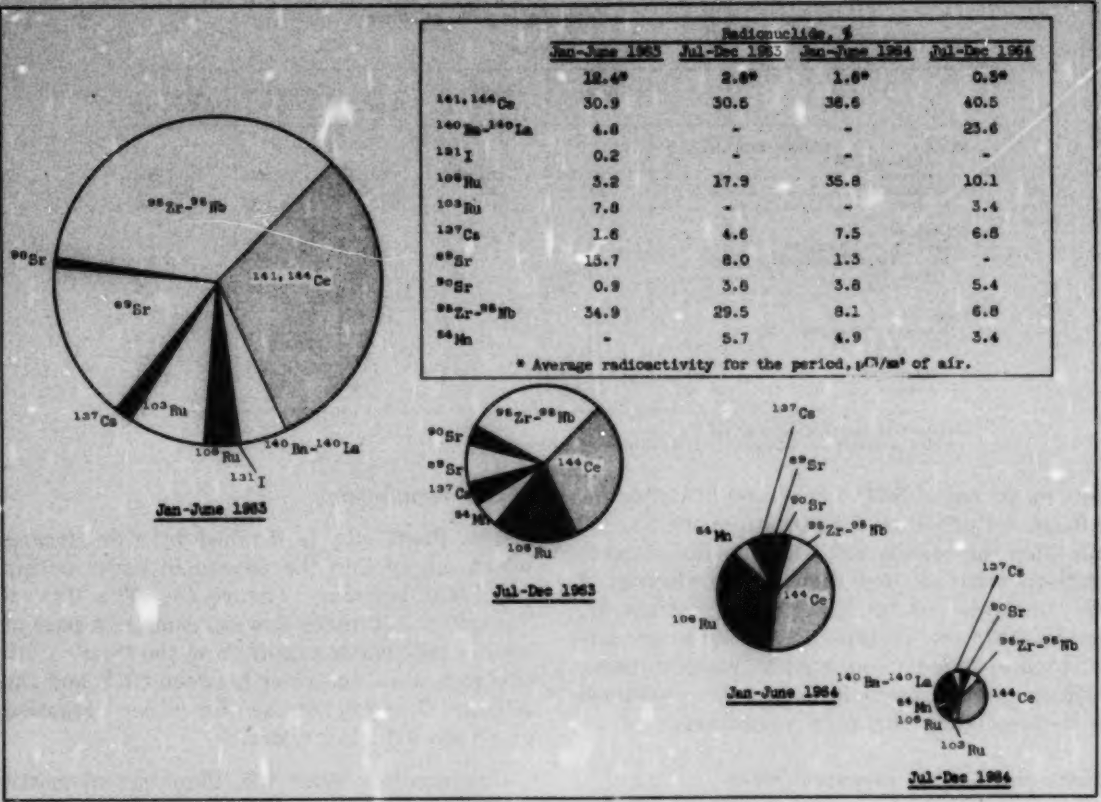
Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or absorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Table 2. Total fallout deposited, second half of 1964

(mCi/sq mi)

Radionuclide	Plant perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Av	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Av
Alpha [a]	4.9	8.9	6.0	9.5	7.2	7.3	9.1	4.2	7.3	1.4	9.1	6.8	8.7	7.4	5.8	6.6
^{90}Sr	3	3	5	5	4	4	5	3	5	2	5	5	6	4	4	4
^{137}Cs	11	9	10	13	12	11	11	10	11	3	9	11	10	8	13	10
^{144}Ce	15	32	27	37	38	30	22	19	27	11	30	24	29	23	38	25
^{106}Ru	3	4	6	6	6	5	5	4	5	1	6	5	3	2	4	4
^{103}Ru	9	11	13	16	16	13	16	10	14	9	13	12	18	14	18	14
^{95}Zr-Nb	2	2	2	2	3	2	3	2	3	1	3	3	3	2	6	3
^{54}Mn	3	3	4	5	5	4	5	4	5	2	5	5	4	3	10	5

[a] Multiply by 10^{-3}.



	Radionuclide, %			
	Jan-June 1963	Jul-Dec 1963	Jan-June 1964	Jul-Dec 1964
	12.4*	2.8*	1.8*	0.5*
^{141,144}Ce	30.9	30.5	38.6	40.5
^{140}Ba-^{140}La	4.8	-	-	23.6
^{131}I	0.2	-	-	-
^{106}Ru	3.2	17.9	35.8	10.1
^{103}Ru	7.8	-	-	3.4
^{137}Cs	1.6	4.6	7.5	6.8
^{89}Sr	15.7	8.0	1.3	-
^{90}Sr	0.9	3.8	3.8	5.4
^{95}Zr-^{95}Nb	34.9	29.5	8.1	6.8
^{54}Mn	-	5.7	4.9	3.4

* Average radioactivity for the period, pCi/m³ of air.

Figure 5. Relative abundance of airborne radionuclide activity (weapons test fallout)

Grass samples were collected at 7 locations along the plant perimeter and at 7 other locations along a 25-mile radius route. (These are not designated on figure 2.) Samples from each quadrant of the plant and of the surrounding area were composited for weekly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.1 pCi/gram at plant perimeter and 25-mile radius locations; gamma emitters averaged 56 pCi/gram and 37 pCi/gram, respectively. Radionuclide concentrations comprising gamma activity are presented in table 3.

Milk

Milk was sampled at 4 dairies within a 25-mile radius of the plant, as shown in figure 2. Samples were taken weekly and analyzed for tritium, iodine–131, and cesium–137. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1964 are given in table 4.

Average concentrations of radionuclides in

Table 3. Radioactivity on vegetation, pCi/g

	Alpha	^{137}Cs	^{144}Ce	^{106}Ru	^{95}Zr-Nb	^{54}Mn
Sensitivity of analysis	0.10	0.07	0.32	0.45	0.06	0.05
Plant perimeter (7 locations)						
Maximum	0.52	16	139	11	4	10
Average	.11	6	42	4	1	3
25-Mile radius (7 locations)						
Maximum	0.64	4	65	8	2	4
Average	.14	3	23	7	<1	3

Table 4. Radioactivity in milk, pCi/liter

(Local dairies)

	Aiken	Allendale	North Augusta	Waynesboro, Georgia	Major Distributors [b]
Tritium MPC: 300,000; Sensitivity of Analysis: 3,000					
Maximum	10,000	20,000	12,000	15,000	21,000
Minimum	(a)	(a)	(a)	(a)	(a)
Average	(a)	(a)	(a)	3,000	3,000
Strontium^{90}					
Sensitivity of Analysis: 1.0					
Daily Intake Guide: 200 pCi/day					
Sept 1964	36	44	40	42	38
Dec 1964	26	22	33	26	29
Cesium^{137}					
Sensitivity of Analysis: 25					
MPC: 2,000					
Maximum	160	165	140	138	131
Minimum	78	<32	<32	<32	56
Average	109	73	78	61	88

[a] Less than sensitivity of analysis.
[b] Milk produced in local dairies but sold by major distributors.

milk measured at SRP were 3,000 pCi/liter for tritium, 34 pCi/liter for strontium–90, and 82 pCi/liter for cesium–137. Radioiodine concentrations were all less than the sensitivity of the analysis (5 pCi/liter). Strontium–90, cesium–137, and iodine–131 in milk are attributed to fallout from nuclear weapons tests. Tritium when present in local milk is assumed to be associated with plant operations.

Algae and fish in Savannah river

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream, adjacent to, and downstream from the Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and form a part of the food chain of aquatic organisms. Data from analysis of fish and algae samples are given in table 5. Beta concentrations in algae adjacent to and downstream from the plant indicate some plant contribution; however, the slight increase is of no biological significance.

Water monitoring

The Plant site is drained by five streams which empty into the Savannah River within the Plant boundary (figure 6). The City of Savannah, 130 miles downstream, gets part of its domestic water supply from the river. With this exception, the river between SRP and the Atlantic Ocean is not used for either irrigation or public drinking water.

Communities near the Plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed monthly; concentrations of alpha activity (1.6 pCi/liter) and beta activity (6.4 pCi/liter) were essentially the same as those observed before plant startup in 1951. Data from analyses of all public water samples are given in table 6.

River water, analyzed weekly, was sampled continuously at 4 locations (upstream, adjacent to, and as far as 10 miles downstream) as shown in figure 2. Concentrations of alpha and nonvolatile beta emitters in river water for the

Table 5. Radioactivity in Savannah River aquatic specimens, pCi/g

Location	Algae (dry weight)				Fish (wet weight)						
	Samples	Max	Min	Av	Samples	Bone			Flesh		
						Max	Min	Av	Max	Min	Av
Nonvolatile Beta Emitters											
Sensitivity of Analysis: Varied due to differing sample size											
Control (3 miles upstream from Plant)	21	150	45	60	30	60	1	19	9	1	3
Along Plant boundary	18	380	40	100	31	1,100	1	57	20	1	5
Highway 301 crossing (10 miles downstream from Plant)	18	170	50	85	44	120	1	29	36	1	5

Table 6. Radioactivity in public water supplies, pCi/liter

	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Av
Alpha Emitters MPC: 10; Sensitivity of Analysis: 0.2															
Max	3.2	0.3	1.8	0.2	5.0	0.6	2.7	16.0	2.4	3.1	0.4	0.3	0.6	2.0	
Min	0.3	(a)	(a)	(a)	2.0	(a)	0.4	6.5	1.0	0.8	(a)	(a)	(a)	0.4	
Av	1.6	(a)	0.4	(a)	2.8	0.2	1.1	11.0	1.6	1.5	(a)	(a)	0.3	0.9	1.6
Nonvolatile Beta Emitters MPC: 3000; Sensitivity of Analysis: 4.0															
Max	9	(a)	10	(a)	9	(a)	7	40	7	10	18	(a)	(a)	4	
Min	(a)	(a)	(a)	(a)	5	(a)	(a)	20	(a)	(a)	(a)	(a)	(a)	(a)	
Av	(a)	(a)	5	(a)	7	(a)	4	28	5	6	7	(a)	(a)	(a)	6.4

a Less than sensitivity of analysis.

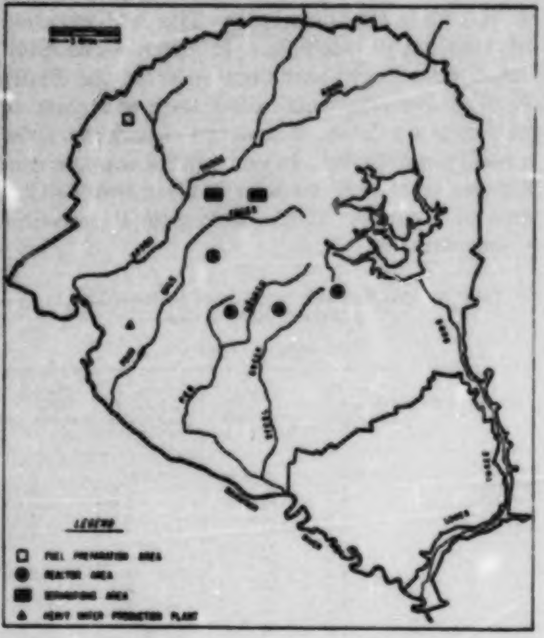


Figure 6. SRP production areas and effluent streams

past year are summarized in table 7; average concentrations of specific radionuclides found in the river water during July–December 1964 are given in table 8.

Radionuclides in river water upstream and downstream from the Plant during the July–December 1964 period are shown in figure 7; the values represent the total quantities of radionuclides passing the two sampling points. Neptunium–239, iodine–131, and chromium–51 are the primary gamma-emitting radionuclides from the Plant. These nuclides, released mainly from the reactor areas, decay rapidly (radioactive half-life less than 30 days). With the exception of strontium–89, most longer lived materials in river water came from nuclear weapons tests. The maximum weekly strontium–89 concentration in river water downstream from the Plant was 5 pCi/liter. Tritium (^3H), a beta emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in reactors. Chromium–51, the second most abundant radionuclide released to the river, is

Table 7. Radioactivity in Savannah River water, pCi/liter

Period data	Control (3 miles upstream from plant)	Plant perimeter		Highway 301 (10 miles downstream from plant)
		1	2	
Alpha Emitters MPC: 10; Sensitivity of Analysis: 0.2				
July-Dec 1964: Max	1.0	0.6	0.4	0.5
Min	(a)	(a)	(a)	(a)
Av	0.3	0.2	(a)	(a)
Jan-June 1964: Av	0.3	(a)	(a)	(a)
Nonvolatile Beta Emitters MCP: 3000; Sensitivity of Analysis: 4.0				
July-Dec 1964: Max	25	38	29	31
Min	(a)	6	8	7
Av	10	15	14	14
Jan-June 1964: Av	12	20	21	21

a Less than sensitivity of analysis.

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produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues; their concentrations in river water were 4 percent and 0.003 percent of their respective MPC's. Average concentrations of all radionuclides found in river water during July–December 1964, as shown in table 8, were only small fractions of the permissible concentrations.

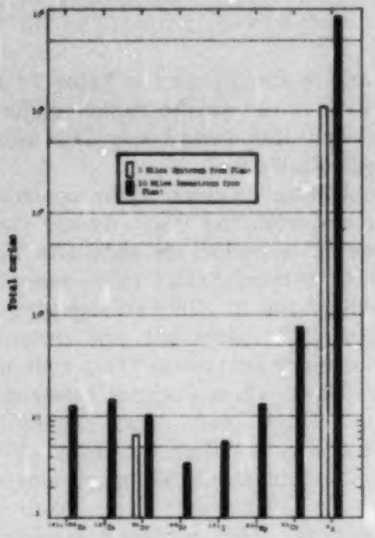

Figure 7. Radionuclides in river water during July–December 1964. (Only ^{90}Sr and ^{3}H were detectable upstream.)

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. January–June 1964 data in table 9 are characteristic of individual station observations during the past several years; the readings are not precise but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variance anticipated due to differences in normal background and in instrument response characteristics.

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by worldwide fallout from nuclear weapons testing during past years. Beta activity in air, which shows no relationship to plant operations, was about one-eighth of that for the same period of 1963. Radionuclides in milk were at the same levels as those reported for most sections of the United States by the U. S. Public Health Service. The concentration of radioactive materials in river algae indicated some slight contribution from the Plant. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. In no instance was the concentration of radionuclides in river water in excess of 4 percent of the Maximum Permissible Concentration.

Table 8. Average concentration of radionuclides in Savannah River water

(Concentration, pCi/liter)

Radionuclide	Sensitivity of Analysis	Control (3 miles upstream from Plant)	Highway 301 (10 miles downstream from Plant)	Percent MPC at Highway 301
^{3}H	600	1,600	12,000	4.0
^{103,106}Ru	3.2	(a)	3.5	0.11
^{141,144}Ce	2.5	(a)	5.0	0.16
^{134,137}Cs	0.6	(a)	3.2	0.16
^{239}Np	0.9	(a)	3.0	0.01
^{140}Ba-La	1.6	(a)	(a)	—
^{95}Zr-Nb	0.5	(a)	(a)	—
^{51}Cr	4.3	(a)	18.0	0.003
^{89}Sr	0.3	(a)	0.4	(a)
^{131}I	0.5	(a)	1.5	(a)
^{90}Sr	0.01	1.1	1.7	(a)
^{60}Co	1.4	(a)	(a)	—
^{65}Zn	1.1	(a)	1.2	0.01
^{54}Mn	0.4	(a)	(a)	—

[a] Less than sensitivity of analysis.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
July–December 1961	*September 1962*
Calendar Year 1962	*August 1963*
Calendar Year 1963	*August 1964*
January–June 1964	*February 1965*

Table 9. Environmental gamma radiation

(mR/24 hours)

	Plant perimeter locations						25-mile-radius locations									
	A	B	C	D	E	Av	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush-Field	Langley	Sardis	Waynesboro	Williston	Av
Max	0.40	0.38	0.38	0.41	0.38		0.37	0.41	0.42	0.43	0.43	0.38	0.37	0.33	0.45	
Min	0.30	0.29	0.27	0.26	0.25		0.33	0.24	0.26	0.28	0.35	0.34	0.31	0.30	0.29	
Av	0.36	0.33	0.33	0.36	0.33	0.34	0.35	0.32	0.33	0.36	0.39	0.36	0.34	0.32	0.38	0.34

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3. Shippingport Atomic Power Station[5] Calendar year 1964

Duquesne Light Company
Shippingport, Pennsylvania

Environmental radiation monitoring at the Shippingport Atomic Power Station began with a two-year preoperational survey program to establish background levels at the site of the world's first large-scale nuclear-powered electric generating station. Following initial operation of the Plant in December 1957, this program was continued as originally conceived through the third quarter of 1961, when it was determined that fewer sampling locations closer to the Plant would provide equal or better evaluation of the effects of plant operation on the environment. The present program of environmental monitoring consists of measurements of radioactivity in air, fallout, and Ohio River water. Figure 8 shows the sampling locations for 1964.

Release of radioactive materials, January–June 1964

During the first six months of 1964, a total of 0.403 Ci of liquid radioactive waste (exclusive of tritium), 0.887 Ci of tritium and 2.4 Ci of xenon–133 gas were released into the environment at concentrations less than those given in the AEC Manual (see footnote 1, p. 456). The six-month average concentration of gross radioactivity in the liquid effluent was 9.3 pCi/liter, and that for tritium was 20 pCi/liter. Xenon–133 was released at a concentration no greater than 3,400 pCi/m^3 air.

An incinerator for burning contaminated combustible material is located in the waste disposal building. The exhaust from the incinerator passes through a wet scrubber and a filter before entering the stack. The average gross radioactivity of incinerator effluent ranged from 3.8 to 11.0 pCi/m^3. These concentrations did not exceed the MPC for unidentified radioactivity (100 pCi/m^3).

Release of radioactive materials, July–December 1964

During the second six months of 1964 a total of 0.130 Ci of liquid radioactive waste (exclusive of tritium), 0.505 Ci of tritium, and 0.312

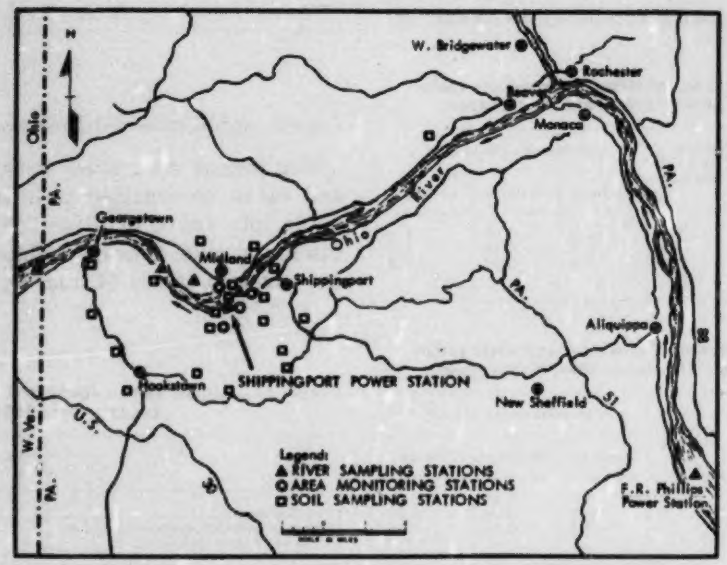
N
Ohio
PA.
W. Va.
PA.
W. Bridgewater
Rochester
Beaver
Monaca
Ohio River
PA.
Georgetown
Midland
Shippingport
PA.
Aliquippa
Hookstown
SHIPPINGPORT POWER STATION
New Sheffield
51
U.S.
Legend:
▲ RIVER SAMPLING STATIONS
◉ AREA MONITORING STATIONS
▢ SOIL SAMPLING STATIONS
F.R. Phillips Power Station

Figure 8. Shippingport Power Station, sampling locations

mCi of airborne radioactivity were released into the environment at concentrations less than those recommended by State and Federal regulations. The six-month average concentration of gross radioactivity in the liquid effluent was 5.83 pCi/liter and that for tritium was 22.6 pCi/liter. The airborne radioactivity was released at air concentration no greater than 100 pCi/m³.

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[5] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Stations for the First Half of 1964" (PNRO–DEV–B1) and "Environmental Radioactivity at the Shippingport Atomic Power Station for the Second Half of 1964 and Calendar Year, 1964". (PNRO–DEV–133).

During the second half of 1964, no radioactive gas was released to the atmosphere. However, small amounts of airborne particulate radioactivity were released from incinerator operations and the exhausts of several ventilation systems. The incinerator operated only during the months of July and August, releasing an estimated radioactivity of 0.044 mCi at a maximum concentration of 9.8 pCi/m³. This concentration is well within the MPC for unidentified radioactivity (100 pCi/m³).

Air monitoring

Airborne particulates are sampled at three area monitoring stations by means of a continuously moving paper tape sampler with an end-window Geiger-Mueller detector and recorder. A one-half hour decay time is allowed before counting, hence, naturally occurring radon and thoron daughters would be present. Maximum, minimum and average concentrations for the six month periods are given in tables 10 and 11.

Table 10. Concentration of airborne particulate radioactivity during January–June 1964, Shippingport

Station number	Percent of time not working	Concentration in pCi/m³		
		Maximum	Minimum	Average
1	42	7.8	0.08	1.4
2	38	7.9	0.08	1.7
3	38	6.9	0.08	1.2
(MPC = 100pCi/m³)				

Table 11. Concentration of airborne particulate radioactivity during July–December 1964, Shippingport

Station number	Percent of time not working	Concentration in pCi/m³		
		Maximum	Minimum	Average
1	54	7.8	0.24	2.30
2	27	62.8	0.24	5.66
3	4	10.4	0.08	2.46
(MPC = 100pCi/m³)				

Area monitoring stations 1, 2, and 3 are located as shown in figure 8.

Fallout sample

Monthly pot samples were collected at each of the three area monitoring stations (same locations as for air). Maximum, minimum, and average monthly deposition rates are given in tables 12 and 13.

Table 12. Gross beta in fallout, Shippingport average monthly deposition, January–June 1964

Station number	Deposition, nCi/m²		
	Maximum	Minimum	Average
1	211.5	35.5	92.6
2	137.4	28.6	83.0
3	197.2	38.6	96.1
Average			90.6

Table 13. Gross beta in fallout, Shippingport average monthly deposition, July–December 1964

Station number	Deposition, nCi/m²		
	Maximum	Minimum	Average
1	52.1	5.87	13.4
2	61.0	5.98	28.6
3	62.5	4.13	26.1
Average			22.7

Liquid radioactive waste disposal

Continuous controlled discharges of tritium and other unidentified radioactive wastes are made into the Ohio River. The quantities of discharge and average effluent concentration are given in tables 14 and 15.

Table 14. Liquid wastes discharged into the Ohio River, January–June 1964

	Tritium	Unidentified radioactivity
Total discharge (Ci)	0.877	0.403
Average of monthly average concentrations of effluent (pCi/liter)	20.0	9.3

Table 15. Liquid wastes discharged into the Ohio River, July–December 1964

	Tritium	Unidentified radioactivity
Total discharge (Ci)	0.505	0.130
Average of monthly average concentrations of effluent (pCi/liter)	22.6	5.83

Ohio River water monitoring

River water samples were collected by a continuous sampler upstream at the Shippingport condenser cooling water-intake and by grab sampling downstream at the condenser cooling-water outfall. (The downstream continuous sampler was not functioning.) These samples were analyzed weekly for both alpha and beta, suspended and dissolved radioactivity. The six-month averages of these measurements are given in tables 16 and 17. When these data are compared to previous monitoring data, including that taken prior to plant operation, there is no evidence that indicates that the liquid waste discharges have had any detectable effect on the level of radioactivity in the Ohio River.

Table 16. Radioactivity in Ohio River water, average concentrations in pCi/liter, January–June 1964

Location		Alpha	Beta
Upstream	Suspended solids	0.53	34.2
Downstream	Suspended solids	0.60	36.4
Upstream	Dissolved solids	0.61	40.1
Downstream	Dissolved solids	0.78	43.2

Table 17. Radioactivity in Ohio River water, average concentrations in pCi/liter, July–December 1964

Location		Alpha	Beta
Upstream	Suspended solids	0.13	13.1
Downstream	Suspended solids	0.26	25.1
Upstream	Dissolved solids	0.48	19.1
Downstream	Dissolved solids	0.56	26.8

Previous coverage in *Radiological Health Data:*

Period	*Issue*
January–June 1961	*April 1962*
July 1962–June 1963	*March 1964*
July–December 1963	*November 1964*

REPORTED NUCLEAR DETONATIONS, JULY 1965

During July 1965 the Atomic Energy Commission announced a nuclear test at the Nevada Test Site. The test was conducted underground on July 23, 1965, and was in the low-intermediate yield range (20 to 200 kilotons).

RADIOLOGICAL HEALTH DATA

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SEPTEMBER 1965

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

DIETARY INTAKES AND BODY BURDENS OF CESIUM-137. *Rivera, J.* (Health and Safety Division, Atomic Energy Commission). Radiological Health Data. Vol. 6, September 1965, pp. 504–506.

Observed and calculated levels of cesium-137 body burdens from intake data were in relatively close agreement, suggesting usefulness of diet data in estimating body burden, and suggesting that retention is described reasonably well as a single exponential function. It is expected that more accurate predictions will be possible when losses of cesium-137 during ashing are better known and with more frequent food sampling.

STRONTIUM-90 IN CANADIAN WHEAT FROM THE 1963 CROP YEAR. *Samuels, E. R.* (Canadian Department of National Health and Welfare). Radiological Health Data, Vol. 6, September 1965, pp. 506–508.

Analyses of Canadian hard red spring wheat obtained from nine major wheat-growing areas showed significant variations in strontium-90 levels in wheat from the different geographical areas, ranging from 143 to 315 pCi strontium-90/kilogram of wheat. On the whole, the highest strontium-90 levels were found in wheat from the northern growing areas. The 1963 average strontium-90 concentration for all Canadian wheat increased by a factor of three over that observed in 1962. This increase was attributed to extensive atmospheric testing in late 1962 and the 1964 results were expected to reflect the subsequent decline in atmospheric nuclear testing.

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Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess total human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

1. Radiation Surveillance Network
May 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of the naturally occurring radon daughters. The daily field readings are submitted to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are observed, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a strontium-90—yttrium-90 standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 2,000 cpm or higher. The initial four-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the day of collection.[1] The May 1965 average gross beta concentrations in air for RSN stations are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

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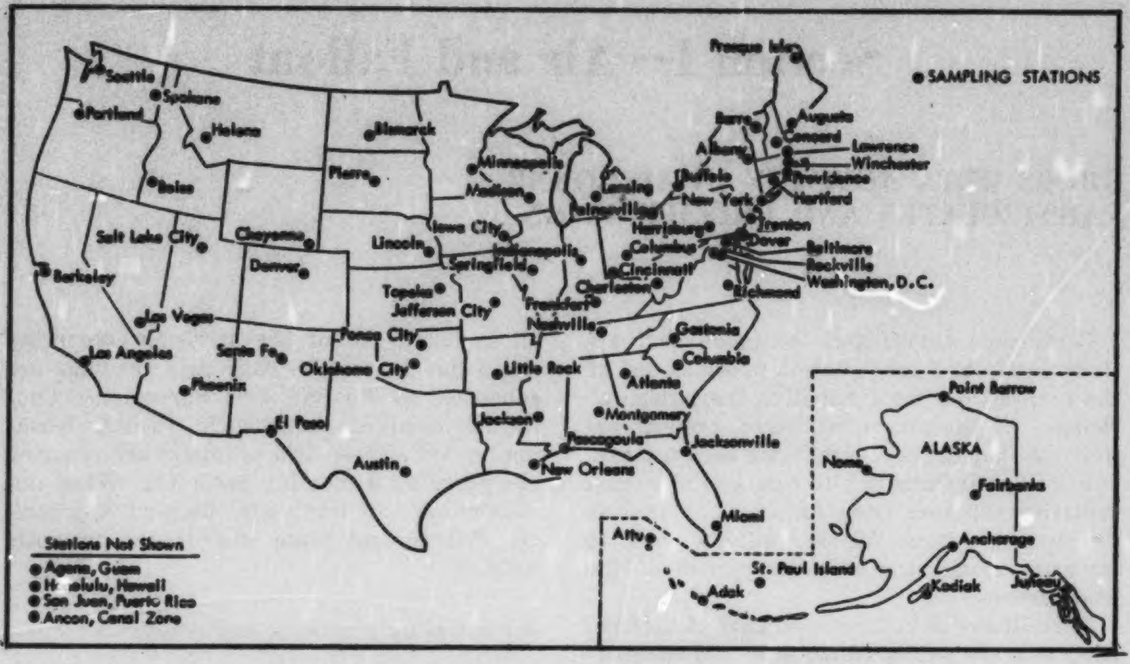
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Denver
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Las Vegas
Los Angeles
Santa Fe
Phoenix
Topeka
Jefferson City
Ponca City
Oklahoma City
Little Rock
El Paso
Austin
Jackson
New Orleans
Pascagoula
Montgomery
Atlanta
Jacksonville
Miami
Frankfort
Nashville
Gastonia
Columbia
Charleston
Cincinnati
Columbus
Harrisburg
Lansing
Painesville
Buffalo
New York
Albany
Barre
Presque Isle
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network Sampling Stations

Radioactivity in precipitation

Continuous sampling for radioactivity in total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition (D) in nCi/m^2 for the sample is determined by:

$$D = \frac{CP}{1000}$$

where C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month. Total depths of precipitation and deposition of radioactivity during May 1965 are presented in table 1.

Observation of fresh fission products

During May 1965, 90 air and precipitation samples were analyzed by gamma spectrometry. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the gamma scan data. Eighty-seven of the samples were found to contain fresh fission products (short-lived radionuclides) in addition to long-lived radionuclides. Although the increases in air activity were not as pronounced as those observed following the first nuclear test on the Chinese mainland, the time relationship between the second detonation that took place on May 13, 1965 (10:00 p.m. EDT) and the influx of the fresh material is reasonably consistent with previous observations.

Table 1. Gross beta activity in surface air and precipitation, May 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition (nCi/m²)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	0.60	<0.10	0.31	May 65	7.4	1.5
Alaska:	Adak	30	0.56	<0.10	<0.17	Jul 65	[b]	
	Anchorage	20	0.30	<0.10	<0.14	May 65	13.4	2.9
	Attu Island	22	0.63	<0.10	<0.15	Dec 64		
	Fairbanks	22	0.54	<0.10	<0.18	Jun 65	1.1	0.3
	Juneau	11	0.30	<0.10	<0.30	Jul 65	20.0	4.0
	Kodiak	8	0.14	<0.10	<0.10	Aug 65		
	Nome	0				Feb 65		
	Point Barrow	31	0.49	<0.10	<0.11	Jan 65		
	St. Paul Island	28	0.62	<0.10	<0.14	Mar 65		
Ariz:	Phoenix	28	8.81	0.19	1.22	Jul 65		
Ark:	Little Rock	26	0.89	<0.10	0.36	Jun 65	52.9	10.7
Calif:	Berkeley	22	0.61	<0.10	0.22	Aug 65		
	Los Angeles	31	0.73	0.18	0.27	Feb 65		
C. Z:	Ancon	0				Aug 65		
Colo:	Denver	28	7.43	0.17	0.93	Aug 65	45.9	11.5
Conn:	Hartford	31	1.08	<0.10	0.29	Jul 65	45.9	11.6
Del:	Dover	25	1.47	<0.10	0.37	May 65		
D. C:	Washington	28	1.56	<0.10	0.40	Feb 65	39.0	11.9
Fla:	Jacksonville	29	0.58	0.18	0.40	Jun 65	17.8	4.4
	Miami	30	0.63	0.15	0.38	Jul 65	2.5	0.5
Ga:	Atlanta	27	0.60	0.13	0.29	Apr 65		
Guam:	Agana	30	17.93	<0.10	1.91	Apr 65		
Hawaii:	Honolulu	31	2.10	<0.10	<0.30	Dec 64	161.2	32.30
Idaho:	Boise	30	1.39	<0.10	0.48	Dec 64	19.2	8.6
Ill:	Springfield	28	0.71	<0.10	0.36	Feb 65	47.5	10.2
Ind:	Indianapolis	28	0.66	0.13	0.35	Apr 65	34.0	15.7
Iowa:	Iowa City	31	2.79	<0.10	0.44	Aug 65	128.0	35.2
Kans:	Topeka	22	2.57	0.11	0.46	May 65	47.5	29.1
Ky:	Frankfort	30	1.48	0.16	0.49	Feb 65	32.8	10.2
La:	New Orleans	29	0.85	0.11	0.34	Feb 65	161.1	44.9
Maine:	Augusta	31	1.30	<0.10	0.32	Mar 65	23.5	5.3
	Presque Isle	25	1.48	<0.10	0.28	Aug 65	71.1	19.9
Md:	Baltimore	24	1.53	<0.10	0.45	Jul 65	40.0	9.5
	Rockville	15	1.82	0.17	0.46	Jan 65		
Mass:	Lawrence	31	1.28	<0.10	0.36	May 65	44.5	12.6
	Winchester	24	1.22	<0.10	0.33	Jul 65	41.2	9.9
Mich:	Lansing	31	1.73	<0.10	0.41	Jan 65	25.9	10.4
Minn:	Minneapolis	27	0.91	<0.10	0.29	Apr 65	107.2	41.6
Miss:	Jackson	29	1.09	0.21	0.44	Dec 64	25.7	5.3
	Pascagoula	19	1.04	0.16	0.66	Jul 65		
Mo:	Jefferson City	30	1.06	<0.10	0.37	Apr 65	93.3	39.2
Mont:	Helena	30	2.19	<0.10	0.56	Jul 65	50.3	13.8
Nebr:	Lincoln	17	2.02	<0.10	0.43	Mar 65	183.7	36.5
Nev:	Las Vegas	27	8.96	0.31	1.44	Jun 65		
N. H:	Concord	25	1.88	<0.10	0.43	Feb 65		
N. J:	Trenton	31	1.42	<0.10	0.41	Mar 65	2.5	1.5
N. Mex:	Santa Fe	28	2.71	0.13	0.64	Jul 65	24.6	9.2
N. Y:	Albany	27	0.77	<0.10	0.30	Apr 65	21.9	4.2
	Buffalo	22	1.51	<0.10	0.45	Aug 65		
	New York	29	1.30	<0.10	0.27	Jul 65		
N. C:	Gastonia	30	0.65	0.11	0.29	Aug 65	49.9	10.0
N. Dak:	Bismarck	29	1.55	<0.10	0.41	Jan 65	161.7	67.9
Ohio:	Cincinnati	7	0.54	0.19	0.31	May 65		
	Columbus	29	2.48	0.15	0.63	Mar 65	89.4	55.7
	Painesville	29	1.39	<0.10	0.43	Jul 65	86.8	25.4
Okla:	Oklahoma City	28	1.10	<0.10	0.36	Jan 65	104.9	
	Ponca City	29	0.65	<0.10	0.19	Jul 65	31.2	22.1
Ore:	Portland	31	0.88	<0.10	0.38	Mar 65	33.8	6.7
Pa:	Harrisburg	31	1.77	<0.10	0.35	Apr 65	349.2	10.5
P. R:	San Juan	30	0.38	<0.10	<0.13	Mar 65	45.6	62.8
R. I:	Providence	30	1.12	<0.10	0.29	Jan 65	19.5	10.6
S. C:	Columbia	28	1.10	0.12	0.31	Jul 65	34.1	4.2
S. Dak:	Pierre	30	2.63	<0.10	0.47	Jul 65	78.8	15.1
Tenn:	Nashville	30	0.74	<0.10	0.30	Jan 65	225.9	20.6
Tex:	Austin	26	1.32	<0.10	0.34	May 65	8.1	45.4
	El Paso	30	3.60	<0.10	0.68	Jan 65	49.8	1.6
Utah:	Salt Lake City	30	15.56	<0.10	1.52	Feb 65	9.2	44.3
Vt:	Barre	30	1.33	<0.10	0.42	Jun 65	35.8	3.2
Va:	Richmond	30	2.16	<0.10	0.42	Jun 65	25.5	44.3
Wash:	Seattle	31	0.31	<0.10	<0.16	May 65	10.6	44.9
	Spokane	31	1.55	0.11	0.39	Apr 65	50.6	7.9
W. Va:	Charleston	29	0.60	0.12	0.30	Jul 65	41.2	40.3
Wis:	Madison	30	1.48	<0.10	0.31	Jun 65	81.5	54.4
Wyo:	Cheyenne	31	5.62	<0.10	0.82	Jun 65		35.1
Network summary [c]		1986	17.93	<0.10	0.43		60.3	20.3

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

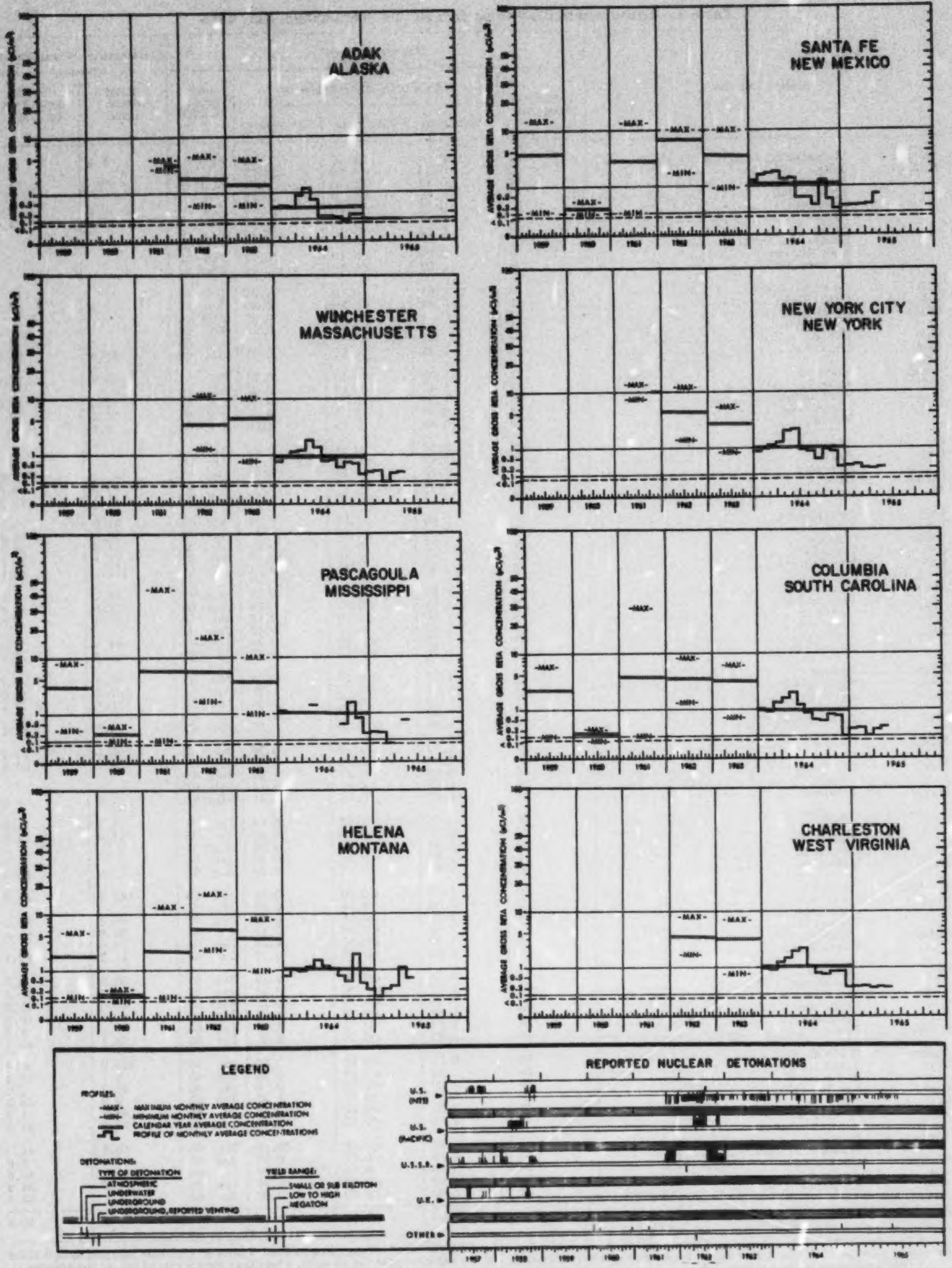

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959—May 1965

2. Canadian Air Monitoring Program[2]
May 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–9*).

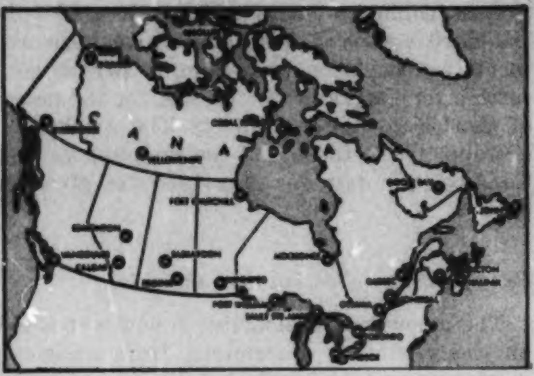

Figure 3. Canadian air and precipitation sampling stations

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high efficiency 4-inch diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa.

For analysis purposes a 2-inch diameter disk is cut from each filter and counted with a thin end-window, gas-flow, Geiger-Mueller counter

Table 2. Canadian gross beta activity in surface air and precipitation, May 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity, pCi/m³			Average concentration, (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	2.2	0.0	0.6	206	9.2
Coral Harbour	31	0.2	0.0	0.1	73	2.2
Edmonton	31	0.6	0.1	0.3	340	25.1
Ft. Churchill	31	0.3	0.0	0.2	85	4.4
Ft. William	24	2.1	0.0	0.4	1,503	114.8
Fredericton	20	1.1	0.0	0.3	172	11.6
Goose Bay	31	0.4	0.0	0.1	114	6.8
Halifax	30	0.5	0.0	0.2	592	13.4
Inuvik	31	5.5	0.1	0.4	114	3.4
Montreal	31	1.5	0.0	0.5	482	22.1
Moosonee	30	2.2	0.0	0.3	323	24.5
Ottawa	30	1.2	0.0	0.3	329	11.9
Quebec	30	1.6	0.0	0.3	370	23.3
Regina	31	1.4	0.0	0.4	423	40.1
Resolute	31	0.3	0.0	0.1	279	1.6
St. John's, Nfld	30	0.4	0.0	0.1	101	8.4
Saskatoon	30	0.3	0.0	0.2	920	19.4
Sault Ste. Marie	31	2.1	0.0	0.4	197	20.8
Toronto	30	1.1	0.1	0.3	446	8.3
Vancouver	30	0.4	0.0	0.2	402	21.0
Whitehorse	31	0.4	0.0	0.2	251	1.9
Windsor	30	1.9	0.1	0.5	403	26.9
Winnipeg	30	1.7	0.0	0.3	565	51.6
Yellowknife	28	6.4	0.0	0.8	Trace	3.2
Average	—	1.5	0.0	0.3	378	19.8

---

[2] This report was prepared from information and data in the June 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

system calibrated with a strontium-90—yttrium-90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for May 1965 are given in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filterate evaporated to near dryness. The filter paper containing insoluble matter is then ignited, together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin end-window Geiger-Mueller counter calibrated with a strontium-90—yttrium-90 source. Gross beta activities in air and precipitation for May 1965 are given in table 2.

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3. Mexican Air Monitoring Program
May 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*10–14*).

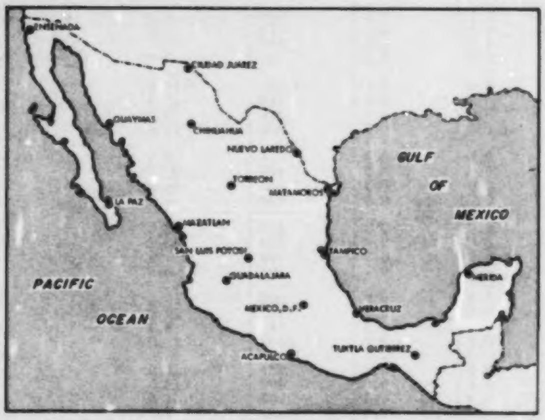

Figure 4. Fallout network sampling stations in Mexico

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. This consists of 17 stations (figure 4), 12 of which are located at airports and operated by airline personnel. The remaining 5 stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactive," CNEN, in Mexico City for assay of gross beta activity. A minimum of three days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during May 1965 are presented in table 3.

Table 3. Gross beta activity of airborne particulates Mexico, May 1965

Station	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	a			
Ciudad Juárez	12	2.2	0.1	0.8
Chihuahua	18	2.9	0.2	0.1
Ensenada	10	0.3	<0.1	0.2
Guadalajara	16	1.6	<0.1	0.3
Guaymas	9	0.6	0.1	0.4
La Paz	19	0.4	0.1	0.2
Matamoros	5	0.3	<0.1	0.2
Mazatlán				
Mérida	12	0.8	<0.1	0.2
México, D.F.	18	2.2	<0.1	<0.1
Nuevo Laredo	2			
San Luis Potosí	13	2.0	<0.1	0.3
Tampico	18	0.2	<0.1	0.1
Torreón	17	1.8	<0.1	0.3
Tuxtla Gutiérrez				
Veracruz				

a Blanks indicate stations temporarily shut down.

4. Pan American Air Sampling Program May 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by six countries in the Americas under the auspices of a collaborative program developed by Pan American Health Organization (PAHO) and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The six air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; in Trinidad, West Indies, by the University of the West Indies; and in Buenos Aires, Argentina, by the Ministry of Social Welfare and Public Health.

The May 1965 air monitoring results from the six participating countries are given in table 4.

Table 4. Gross beta activity in air, PAHO, May 1965

Sampling stations	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average a
Kingston, Jamaica	21	0.31	<0.10	<0.11
Caracas, Venezuela	20	0.16	<0.10	<0.10
Lima, Peru	19	0.10	<0.10	<0.10
Santiago, Chile	29	0.12	<0.10	<0.10
Trinidad, West Indies	0	—	—	—
Buenos Aires, Argentina	0	—	—	—

a The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

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MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and other areas April–December 1964[1]

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 44 sites in the United States and 104 locations in other countries.

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in a stainless steel pot with an exposed area of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.07m^2, attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

Results

Strontium-90 data from all of the United States stations and 26 other selected points in the Western Hemisphere (see figure 1) covering the period from April through December 1964 are summarized in tables 1 and 2. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

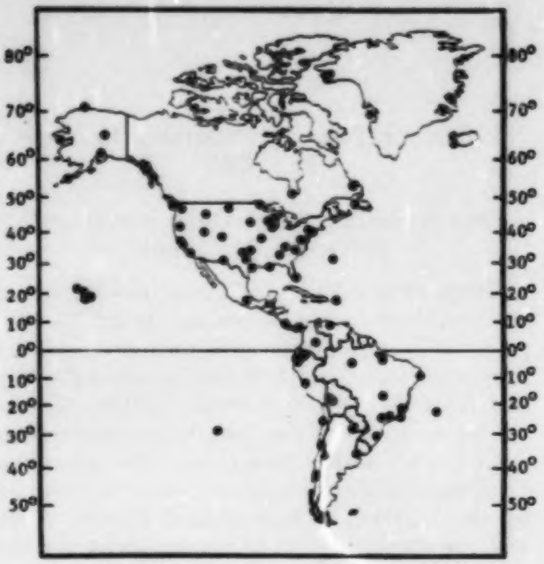

Figure 1. HASL fallout sampling stations

Stations at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have collected monthly pot samples which have been analyzed for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium-89, strontium-90, cesium-137, cerium-144, zirconium-95 and manganese-54 at each station are presented in tables 3 and 4.

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[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL-161*:5–203, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

Table 1. Monthly strontium-90 fallout in the United States, HASL, April–December 1964

(Deposition in nCi/m²)

Sampling location and type of collection		April	May	June	July	August	September	October	November	December
Ala:	Birmingham (pot)	0.29	1.06	2.20	1.35	0.56	0.29	—	—	0.01
Alaska:	Anchorage (col)	0.16	0.22	0.30	—	0.62	0.31	—	—	0.07
	Barrow (col)	[a] —	—	0.25	0.10	0.21	0.02	—	—	[c]
	Cold Bay (col)	0.67	1.15	1.03	1.14	0.90	0.60	—	—	0.43
	Fairbanks (col)	0.22	0.44	1.37	0.01	0.61	0.14	—	—	0.07
	Juneau (col)	—	3.93	2.70	1.21	0.86	0.02	—	—	0.33
	Nome (col)	—	0.39	0.03	0.15	0.05	0.48	—	—	—
Calif:	W. Los Angeles (pot)	0.04	0.03	—	0.02	0.06	0.10	—	—	0.10
	Palo Alto (pot)	0.05	0.22	0.12	0.03	0.08	0.01	0.10	0.33	0.40
	Palo Alto (col)[b]	0.07	0.22	0.12	—	—	—	—	—	—
	San Francisco (col)	0.12	0.21	0.17	0.05	0.04	[c]	—	—	0.52
Colo:	Denver (col)	0.32	1.47	4.38	1.31	0.30	0.19	—	—	0.15
Fla:	Coral Gables (pot)	—	3.02	2.14	0.97	0.53	0.25	0.07	0.05	0.05
	Miami (col)	0.96	2.06	2.00	1.17	0.46	0.30	—	—	0.24
Hawaii:	Hilo (col)	1.99	6.85	0.25	1.85	0.94	0.81	—	—	0.38
	Honolulu (pot)	1.19	1.19	0.70	0.78	0.58	0.42	—	—	0.05
	Lihue (col)	1.73	0.84	4.41	0.78	0.35	0.19	—	—	0.10
	Mauna Loa (col)	0.23	0.23	0.01	0.20	0.06	0.35	—	—	0.09
Ill:	Argonne (pot)	2.74	1.19	3.22	0.80	0.53	0.39	—	—	0.04
La:	New Orleans (col)	1.87	0.47	0.94	0.91	0.44	0.16	—	—	0.17
Minn:	International Falls (col)	1.84	3.05	0.40	1.58	0.81	0.20	—	—	0.07
Mo:	Columbia (col)	1.68	3.74	1.87	1.34	0.30	0.29	—	—	0.14
Mont:	Helena (col)	0.46	1.43	2.76	1.09	0.59	0.17	—	—	0.10
N. J:	Westwood (pot)	2.58	0.86	2.29	1.07	0.43	0.11	0.31	0.34	—
	Westwood (col)	—	0.80	1.84	—	—	—	—	—	—
N. Y:	New York (pot)	4.73	0.53	2.55	1.28	0.39	0.25	0.29	0.32	0.56
N. Dak:	Williston (col)	0.29	0.72	2.94	0.34	0.49	0.20	—	—	0.24
Ohio:	Wooster (pot)	3.14	3.03	3.04	1.35	0.75	0.12	—	—	0.09
Okla:	Midwest City (pot)	1.23	2.54	0.73	0.46	0.54	0.42	0.36	0.46	0.04
	Tulsa (pot)	[d] 1.31	[d] 1.60	1.67	1.21	—	—	—	—	—
Ore:	Medford (col)	0.19	0.35	1.04	0.95	0.32	0.07	—	—	0.94
S. C:	Columbia (col)	0.74	1.14	1.34	1.54	0.48	0.28	—	—	0.32
S. Dak:	Vermillion (pot)	4.22	2.84	4.58	1.27	0.02	0.47	—	—	0.03
Tenn:	Chattanooga (pot)	4.40	2.11	1.43	0.86	0.73	0.19	0.43	0.21	0.05
Tex:	Dallas (col)	1.57	2.02	0.61	0.22	0.34	0.25	—	—	0.11
	El Paso (col)	0.34	0.05	0.19	0.39	0.17	0.27	—	—	0.07
	Houston (col)	0.38	0.54	0.49	1.76	0.21	0.09	—	—	0.24
Utah:	Salt Lake City (pot)	5.70	2.31	6.58	1.62	0.31	—	—	—	0.14
Va:	Sterling (U.S. Weather Bureau Center) (col)	1.89	0.71	0.81	0.76	0.33	—	—	—	0.32
Wash:	Seattle (pot)	1.54	1.87	1.15	0.68	0.33	0.30	0.18	0.80	0.63
	Seattle (pot)	1.47	1.83	2.56	0.85	0.48	0.35	—	—	0.12
	Tatoosh Island (col)	0.15	0.91	1.59	1.12	0.66	0.47	—	—	0.98
Wis:	Appleton (pot)	1.35	2.46	0.77	1.19	0.71	0.65	0.38	0.45	0.16
	Green Bay (col)	1.44	1.73	1.59	1.39	0.78	0.35	—	—	0.15

[a] Dash indicates data not available.
[b] Collection discontinued after June 1964.
[c] Zero or trace.
[d] Proportioned from originally consolidated data.

Table 2. Monthly strontium-90 fallout in North and South America, HASL, April–December 1964

(Deposition in nCi/m²)

Sampling location and type of collection		April	May	June	July	August	September	October	November	December
Bermuda:	Kindley AFB (col)	0.42	0.79	0.12	0.47	0.56	0.05	[a] —	—	0.37
Bolovia:	Chacaltaya (col)	0.02	0.02	0.04	0.02	0.01	0.07	—	—	0.05
	La Paz (Ovejuyo) (col)	0.03	0.03	0.01	0.07	0.03	0.07	—	—	0.10
	La Paz (City) (col)	0.02	0.02	0.01	0.03	0.03	0.07	—	—	0.08
Brazil:	Belem (col)	0.18	0.36	0.09	0.10	0.06	0.08	—	—	0.01
	Trinidade Island (col)	0.01	0.06	0.59	0.16	0.19	—	—	0.26	—
Canada:	Moosonee (col)	1.06	2.54	3.13	1.16	1.37	0.46	—	—	0.06
	Ernest Harmon AB (col)	1.27	1.07	2.22	1.73	0.67	0.37	—	—	0.14
	Goose Bay AB (col)	[b] —	—	—	—	—	—	—	—	—
Canal Zone:	Miraflores (col)	0.24	0.34	0.04	0.17	0.15	0.13	—	—	—
Chile:	Antofagasta (col)	0.02	0.02	0.02	0.02	0.02	0.01	—	—	[c]
	Puerto Montt (col)	0.10	0.36	0.27	0.32	0.24	—	—	0.33	0.52
	Punta Arenas (col)	0.03	0.10	0.02	—	—	0.12	—	—	0.25
	Santiago (pot)	0.02	0.03	0.05	0.21	—	0.03	[c]	[c]	—
	Santiago (col)	0.03	[b] —	0.44	0.13	0.42	—	—	—	—
Colombia:	Bogota (pot)	[d] 0.10	0.03	0.07	—	0.05	[c]	—	—	—
Costa Rica:	Turrialba (col)	0.11	0.37	0.25	0.31	0.16	0.05	—	—	0.11
Ecuador:	Guayaquil (col)	0.06	0.08	0.01	0.01	0.01	0.02	—	—	0.03
	Quito (col)	—	0.03	0.02	0.03	0.02	—	—	—	0.03
Greenland:	Thule (col)	0.13	0.07	0.19	0.63	0.13	—	—	—	0.04
Iceland:	Keflavik (col)	0.42	0.58	2.38	1.31	0.31	0.21	—	—	0.21
Mexico:	Mexico City (col)	—	—	—	—	—	—	—	—	0.01
Peru:	Lima (col)	0.02	0.02	0.03	0.05	—	—	—	0.05	—
	Lima (col)	0.01	0.03	0.02	0.05	0.06	0.02	—	—	0.02
Puerto Rico:	San Juan (col)	1.19	0.76	0.87	[d] 0.66	[d] 0.63	0.21	—	—	0.32
Venezuela:	Caracas (col)	0.17	0.17	0.29	0.51	0.15	0.10	—	0.03	0.07
	Caracas (col)	0.25	[d] 0.16	[d] 0.16	[d] 0.16	0.10	0.18	—	—	0.06

[a] Dash indicates data not available.
[b] Collection discontinued after February 1964.
[c] Zero or trace.
[d] Proportioned from originally consolidated data.

Table 3. Precipitation at 6 U.S. sites, HASL, April–December 1964

Sampling location	Precipitation, mm								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
California, Palo Alto	1.02	13.2	13.7	([a])	4.57	([a])	22.1	81.6	131.1
New Jersey, Westwood	155.9	26.7	62.5	120.2	25.4	32.5	34.5	60.9	110.0
Oklahoma, Midwest City	53.4	95.0	17.3	24.4	95.0	88.9	28.9	156.7	17.0
Tennessee, Chattanooga	249.6	125.4	84.4	141.5	157.2	75.7	97.4	86.6	75.7
Washington, Seattle	33.8	35.3	78.0	([b])	24.9	47.2	16.5	113.9	113.9
Wisconsin, Appleton	66.1	135.1	38.4	140.7	61.7	90.8	7.87	54.1	14.0

[a] Zero or trace.
[b] Data not available.

Table 4. Radionuclide analyses of pot fallout samples at 6 U.S. sites, HASL, April–December 1964 Fission product and "tracer" radionuclides in monthly collections

(Deposition in nCi/m^2)

Sampling location	Strontium-89									Strontium-90								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
California, Palo Alto	<0.01	<0.05	<0.02	[a] —	—	—	0.20	0.65	0.08	0.05	0.22	0.12	0.03	0.08	0.01	0.10	0.33	0.49
New Jersey Westwood	—	—	—	—	—	—	0.05	0.26	—	2.58	0.86	2.39	1.07	0.43	0.11	0.31	0.34	—
Oklahoma, Midwest City	<0.67	<0.10	<0.05	—	—	—	0.69	1.59	0.01	1.33	2.54	0.73	0.46	0.54	0.42	0.36	0.46	0.04
Tennessee, Chattanooga	—	—	—	—	—	—	1.51	0.12	0.07	4.40	2.11	1.43	0.86	0.73	0.19	0.43	0.21	0.05
Washington, Seattle	<0.03	0.04	<0.04	<0.01	<0.05	<0.02	0.15	1.43	<0.02	1.54	1.87	1.15	0.68	0.33	0.30	0.18	0.80	0.62
Wisconsin, Appleton	—	—	—	—	—	—	0.19	1.79	0.06	1.35	2.46	0.77	1.19	0.71	0.65	0.38	0.45	0.16
	Cesium-137									Cerium-144								
California, Palo Alto	0.15	0.43	0.14	0.07	0.12	0.04	0.14	0.45	0.67	2.20	4.21	2.04	0.46	0.54	0.15	0.64	1.99	2.67
New Jersey, Westwood	4.48	1.36	4.14	1.86	0.63	0.29	0.46	0.45	—	29.2	8.54	24.0	10.3	3.00	1.85	0.95	1.88	—
Oklahoma, Midwest City	2.14	4.17	1.02	0.68	0.79	0.58	0.51	0.64	0.11	15.1	31.1	9.65	4.25	4.63	3.25	2.29	3.43	0.44
Tennessee, Chattanooga	9.66	3.26	2.52	1.27	0.80	0.34	0.45	0.16	0.13	64.9	26.4	13.0	0.97	10.9	lost	3.63	1.85	0.50
Washington, Seattle	1.89	2.40	1.73	1.03	0.53	0.57	0.29	0.88	0.91	14.7	12.3	9.73	6.02	3.00	2.70	1.67	3.82	3.44
Wisconsin, Appleton	2.37	4.17	1.31	2.28	1.20	1.14	0.30	0.70	0.26	16.8	29.0	0.74	13.6	0.74	0.64	1.72	3.17	1.06
	Zirconium-95									Manganese-54								
California, Palo Alto	0.05	0.09	0.08	0.04	0.02	0.02	0.11	0.20	0.05	0.08	0.15	0.07	0.04	0.02	<0.02	0.06	0.23	0.30
New Jersey, Westwood	1.87	0.34	0.52	0.23	0.13	<0.03	0.05	0.65	—	2.53	1.00	1.90	0.81	0.15	0.14	0.05	0.23	—
Oklahoma, Midwest City	0.21	0.60	0.10	0.08	0.08	0.07	0.36	0.32	0.03	1.07	2.60	0.58	0.36	0.31	0.36	0.24	0.34	0.05
Tennessee, Chattanooga	3.34	1.04	0.49	0.23	0.15	0.03	0.74	<0.01	<0.03	4.02	2.12	1.26	0.76	0.19	0.07	0.37	0.15	0.06
Washington, Seattle	0.77	0.51	0.32	0.15	0.03	0.05	0.12	0.34	0.09	1.49	1.67	1.08	0.67	0.29	0.23	0.15	0.37	0.33
Wisconsin, Appleton	0.98	0.97	0.26	0.29	0.15	0.11	0.43	0.29	0.04	1.20	2.85	0.73	0.88	0.33	<0.15	0.07	0.30	0.09

[a] Dash indicates data not available.

2. Fallout measurements in Canada October–December 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling program described earlier in this issue represent total fallout (wet and dry). The radiochemical analyses of these samples for October through December 1964 are given in table 5.

In general, the results show a continuation of the slow downward trend in fallout levels which has been evident in the past several months. A review and discussion of fallout levels in Canada during 1964 has been presented by Booth, *et al.* (*2*).

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Table 5. Radionuclide deposition (nCi/m^2) in Canadian fallout, October–December 1964

Station	October					November					December [b]	
	^{89}Sr	^{90}Sr	^{137}Cs	^{95}Zr	^{140}Ba	^{89}Sr	^{90}Sr	^{137}Cs	^{95}Zr	^{140}Ba	^{90}Sr	^{137}Cs
Calgary	0.95	0.30	0.47	0.83	3.51	0.10	0.08	0.25	0.16	0.12	0.05	0.13
Coral Harbour	0.00	0.10	0.14	[a] NA	NA	0.42	0.32	0.44	NA	NA	0.02	0.04
Edmonton	1.60	0.16	0.28	NA	NA	0.12	0.20	0.30	NA	NA	0.11	0.22
Ft. Churchill	0.18	0.12	0.36	NA	NA	0.16	0.11	0.22	NA	NA	0.03	0.15
Ft. William	1.35	0.40	0.75	NA	NA	0.00	2.33	0.85	NA	NA	0.26	0.36
Fredericton	1.32	0.49	0.94	NA	NA	0.11	0.28	0.17	NA	NA	0.26	0.61
Goose Bay	0.49	0.29	0.51	NA	NA	0.25	0.16	0.10	NA	NA	0.11	0.32
Halifax	1.09	0.53	0.83	0.53	3.38	0.28	0.45	0.92	0.09	0.21	0.33	0.66
Inuvik	0.70	0.25	0.44	NA	NA	0.00	0.06	0.12	NA	NA	0.03	0.15
Montreal	0.90	0.35	0.67	0.32	2.21	0.39	0.29	0.61	0.07	0.26	0.39	0.70
Moosonee	0.48	0.33	0.70	NA	NA	0.29	0.29	0.28	NA	NA	0.10	0.16
Ottawa	0.88	0.21	0.25	NA	NA	0.61	0.32	0.52	NA	NA	0.28	0.29
Quebec	2.94	0.65	0.82	NA	NA	0.25	0.54	0.88	NA	NA	0.50	0.06
Regina	0.11	0.01	0.07	NA	NA	0.10	0.02	0.13	NA	NA	0.08	0.13
Resolute	0.74	0.20	0.46	NA	NA	0.41	0.51	0.85	NA	NA	0.32	0.24
St. John's, Nfld	2.34	0.63	0.83	NA	NA	0.25	0.50	0.45	NA	NA	0.62	0.56
Saskatoon	0.98	0.18	0.36	NA	NA	0.10	0.04	0.13	NA	NA	0.07	0.13
Sault Ste. Marie	0.39	0.45	0.79	NA	NA	0.48	0.58	1.15	NA	NA	0.55	0.85
Toronto	2.26	0.35	0.61	NA	NA	0.10	0.08	0.24	NA	NA	0.39	0.66
Vancouver	0.41	0.35	0.55	0.18	1.53	0.24	0.31	0.51	0.10	0.22	0.65	1.14
Whitehorse	0.15	0.14	0.21	NA	NA	0.15	0.19	0.33	NA	NA	0.02	0.04
Windsor	2.08	0.30	0.54	NA	NA	0.00	0.00	0.04	NA	NA	0.32	0.59
Winnipeg	1.99	0.19	0.38	1.19	7.53	0.15	0.13	0.19	0.04	0.14	0.06	0.16
Yellowknife	0.00	0.20	0.26	NA	NA	0.00	0.06	0.08	NA	NA	0.04	0.06

[a] NA indicates no analysis performed.
[b] Strontium-89, zirconium-95 and barium-140 levels not reported because of insignificantly low levels.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
May 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analysis.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically to determine strontium–89

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

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and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical error (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclides concentrations in milk

Nuclide	Estimated concentration (pCi/liter)	Error [a] (pCi/liter)	Estimated concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	<100	10	100 or greater	10
Barium-140	<100	10	100 or greater	10
Cesium-137	<100	10	100 or greater	10
Strontium-89	<50	5	50 or greater	10
Strontium-90	<20	2	20 or greater	10

[a] Two standard deviations

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for May 1965 (actual reporting period is April 25, 1965, to May 29, 1965). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963, when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

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[2] The conversion factor is 1.18 milligrams K/pCi ^{40}K.

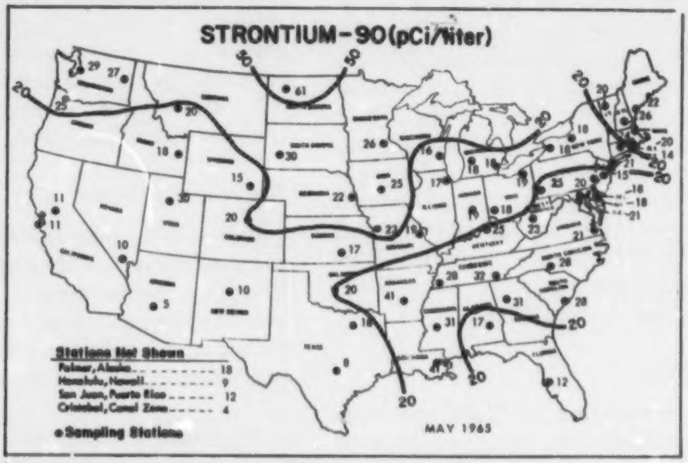

Figure 1. Strontium-90 concentrations in pasteurized milk, May 1965

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, first quarter 1965 and May 1965

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		First quarter	Average for May	First quarter	Average for May	First quarter	Average for May	First quarter	Average for May	First quarter	Average for May
Ala:	Montgomery	1.19	1.19	<5	<5	19	17	55	50	0	0
Alaska:	Palmer	1.18	1.25	<5	<5	17	18	60	70	0	10
Ariz:	Phoenix	1.20	1.23	<5	<5	6	5	25	20	0	0
Ark:	Little Rock	1.18	1.15	<5	<5	34	41	70	65	0	0
Calif:	Sacramento	1.26	1.18	<5	<5	7	10	35	35	0	10
	San Francisco	1.27	1.20	<5	<5	8	11	35	35	0	0
C. Z:	Cristobal	1.14	1.08	<5	<5	5	4	40	35	0	0
Colo:	Denver	1.27	1.38	<5	<5	18	20	70	70	0	0
Conn:	Hartford	1.12	1.10	<5	<5	16	14	90	80	0	0
Del:	Wilmington	1.15	1.15	<5	<5	19	18	80	65	0	0
D. C:	Washington	1.17	1.16	<5	<5	17	18	60	50	0	10
Fla:	Tampa	1.18	1.18	<5	<5	13	12	160	185	0	0
Ga:	Atlanta	1.19	1.14	<5	<5	26	31	90	85	0	0
Hawaii:	Honolulu	1.18	1.22	<5	<5	11	9	65	60	0	0
Idaho:	Idaho Falls	1.21	1.24	<5	<5	21	18	110	100	0	0
Ill:	Chicago	1.12	1.15	<5	<5	17	17	90	30	0	0
Ind:	Indianapolis	1.19	1.16	<5	<5	17	19	75	55	0	0
Iowa:	Des Moines	1.20	1.27	<5	5	22	25	60	60	0	30
Kans:	Wichita	1.24	1.27	<5	<5	18	17	55	40	0	0
Ky:	Louisville	1.17	1.16	<5	<5	22	25	60	40	0	0
La:	New Orleans	1.23	1.21	5	<5	43	41	80	75	0	0
Maine:	Portland	1.14	1.12	<5	<5	22	22	135	130	0	0
Md:	Baltimore	1.16	1.15	<5	<5	18	21	65	60	0	0
Mass:	Boston	1.16	1.13	<5	<5	23	24	140	130	0	0
Mich:	Detroit	1.15	1.15	<5	<5	16	18	85	80	0	0
	Grand Rapids	1.18	1.17	<5	<5	19	18	90	85	0	0
Minn:	Minneapolis	1.22	1.30	<5	10	26	26	90	100	0	10
Miss:	Jackson	1.25	1.17	<5	<5	34	31	60	50	0	0
Mo:	Kansas City	1.22	1.26	<5	5	22	2	60	45	0	40
	St. Louis	1.25	1.28	<5	<5	17	19	50	45	0	10
Mont:	Helena	1.25	1.34	<5	<5	18	20	95	90	0	20
Nebr:	Omaha	1.25	1.21	<5	<5	18	22	50	50	0	10
Nev:	Las Vegas	1.20	1.33	<5	<5	9	10	40	45	0	0
N. H:	Manchester	1.16	1.13	<5	<5	24	26	155	165	0	0
N. J:	Trenton	1.13	1.12	<5	<5	16	15	80	70	0	0
N. Mex:	Albuquerque	1.22	1.25	<5	<5	12	10	45	35	0	0
N. Y:	Buffalo	1.11	1.09	<5	<5	17	18	110	105	0	0
	New York	1.12	1.13	<5	<5	19	21	105	100	0	0
	Syracuse	1.11	1.10	<5	<5	16	18	95	85	0	0
N. C:	Charlotte	1.20	1.18	<5	<5	29	28	65	65	0	0
N. Dak:	Minot	1.21	1.26	<5	<5	52	61	125	125	0	0
Ohio:	Cincinnati	1.16	1.13	<5	<5	17	18	70	45	0	0
	Cleveland	1.16	1.12	<5	<5	18	19	95	75	0	10
Okla:	Oklahoma City	1.18	1.13	<5	<5	21	20	55	45	0	0
Ore:	Portland	1.28	1.33	<5	5	20	25	100	90	0	0
Pa:	Philadelphia	1.16	1.14	<5	<5	17	20	80	65	0	0
	Pittsburgh	1.16	1.12	<5	<5	24	25	105	95	0	0
P. R:	San Juan	1.14	1.09	<5	<5	12	12	50	45	0	0
R. I:	Providence	1.16	1.11	<5	<5	19	20	100	100	0	0
S. C:	Charleston	1.20	1.18	<5	<5	30	28	85	115	0	0
S. Dak:	Rapid City	1.03	1.10	<5	10	28	30	135	110	0	0
Tenn:	Chattanooga	1.22	1.22	<5	<5	31	32	70	60	0	0
	Memphis	1.20	1.16	<5	<5	26	28	45	40	0	0
Tex:	Austin	1.15	1.12	<5	<5	9	8	35	30	0	0
	Dallas	1.19	1.17	<5	<5	18	18	45	40	0	0
Utah:	Salt Lake City	1.30	1.44	<5	<5	25	30	125	130	0	0
Vt:	Burlington	1.12	1.13	<5	<5	21	20	120	110	0	0
Va:	Norfolk	1.19	1.17	<5	<5	21	21	60	65	0	10
Wash:	Seattle	1.26	1.31	<5	<5	23	29	90	110	0	0
	Spokane	1.28	1.29	<5	<5	26	27	100	95	0	0
W. Va:	Charleston	1.18	1.14	<5	5	16	23	50	40	0	10
Wis:	Milwaukee	1.20	1.16	<5	<5	14	16	100	95	0	10
Wyo:	Laramie	1.25	1.25	<5	<5	13	15	65	65	0	0
Network average		1.19	1.19	<5	<5	19.9	21.0	79	74	0	3

[a] Results of barium-140 analyses all zero.

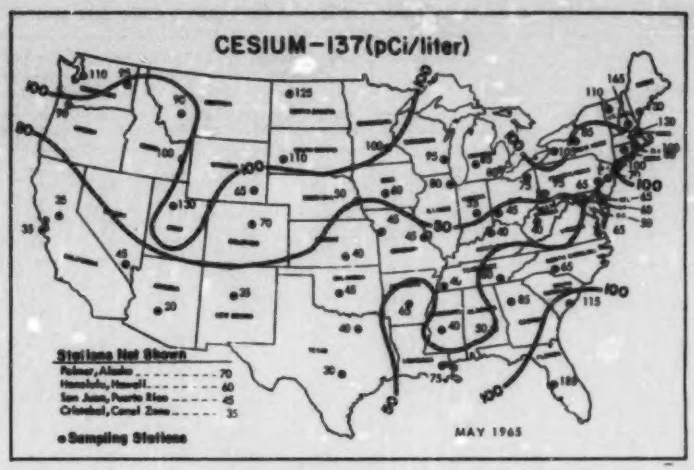

Figure 2. Cesium-137 concentrations in pasteurized milk, May 1965

The distribution of monthly average strontium-90 concentrations as observed in pasteurized milk for December 1964 through May 1965 is presented in table 3. The maximum monthly average concentration of strontium-90 was 61 pCi/liter, observed at Minot, North Dakota. This level is within the lower half of Range II as defined by the Federal Radiation Council (20-200 pCi/liter). The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

Table 3. *Frequency distribution of strontium-90 concentrations in milk at PMN stations, December 1964-May 1965, and May 1964*

Strontium-90 (pCi/liter)	Number of stations						
	1964	1965					1964
	Dec	Jan	Feb	Mar	Apr	May	May
Under 10	8	6	3	5	5	4	3
10-19	29	32	31	29	23	26	8
20-29	20	19	22	21	27	25	20
30-39	4	4	5	6	5	5	20
40-49	2	1	2	1	2	2	6
50-59	0	1	0	1	0	0	4
60-69	0	0	0	0	1	1	1
70-79	0	0	0	0	0	0	1

The Network average cesium-137 concentration in milk for May 1965 was 74 pCi/liter as compared to 82 pCi/liter in April 1965. The maximum monthly average concentration in pasteurized milk was 185 pCi/liter, observed at Tampa, Florida. The distribution of monthly average cesium-137 concentrations in milk for December 1964 through May 1965 is presented in table 4.

Table 4. Frequency distribution of cesium-137 concentrations in milk at PMN stations, December 1964-May 1965, and May 1964

Cesium-137 (pCi/liter)	Number of stations						
	1964	1965					1964
	Dec	Jan	Feb	Mar	Apr	May	May
Under 50	9	11	8	9	7	17	2
50-99	38	38	38	36	35	31	16
100-149	14	12	15	16	18	13	17
150-199	2	2	2	2	3	2	23
200-249	0	0	0	0	0	0	3
250-299	0	0	0	0	0	0	2

The decrease in radionuclide concentrations in milk observed during January through May 1965 can be expected to continue in the absence of atmospheric nuclear testing. This trend is in agreement with concentrations observed from March 1960 through 1964 (*2, 3*).

Perusal of 1965 sampling results indicates no evidence of the anticipated "spring rise" in strontium-90 or cesium-137 concentrations in pasteurized milk.

During May 1965, iodine-131 was observed in weekly milk samples at 19 sampling stations (table 5). The maximum concentration observed was 220 pCi/liter on May 28, 1965. The levels of iodine-131 observed were such that only 13 stations exhibited monthly averages greater than the detection limit of 10 pCi/liter. The highest monthly average, 40 pCi/liter, observed in Kansas City, Missouri, was within Range II as defined by the Federal Radiation Council (10–100 pCi/liter). The presence of iodine-131 in pasteurized milk during May 1965 is presumed a consequence of the mainland China atmospheric nuclear test of May 13, 1965 (10:00 p.m. EDT).

Table 5. Occurrence of iodine-131 in pasteurized milk, May 1965

(Concentration in pCi/liter)

Sampling location		May							
		24	25	26	27	28	29	30	31
Alaska:	Palmer			30					
Calif:	Sacramento					40			
D.C.:	Washington				40				
Hawaii:	Honolulu	20							
Ill:	Chicago		20						
Iowa:	Des Moines				170				
Kans:	Wichita								30
Minn:	Minneapolis		60						
Mo:	Kansas City					220			
	St. Louis				50				
Nebr:	Omaha					70			
N.Y:	Buffalo					20			
N. Dak:	Minot								30
Ohio:	Cleveland					60			
S. Dak:	Rapid City	20							
Tex:	Dallas								20
Va:	Norfolk					40			
W. Va:	Charleston					30			
Wis:	Milwaukee		50						

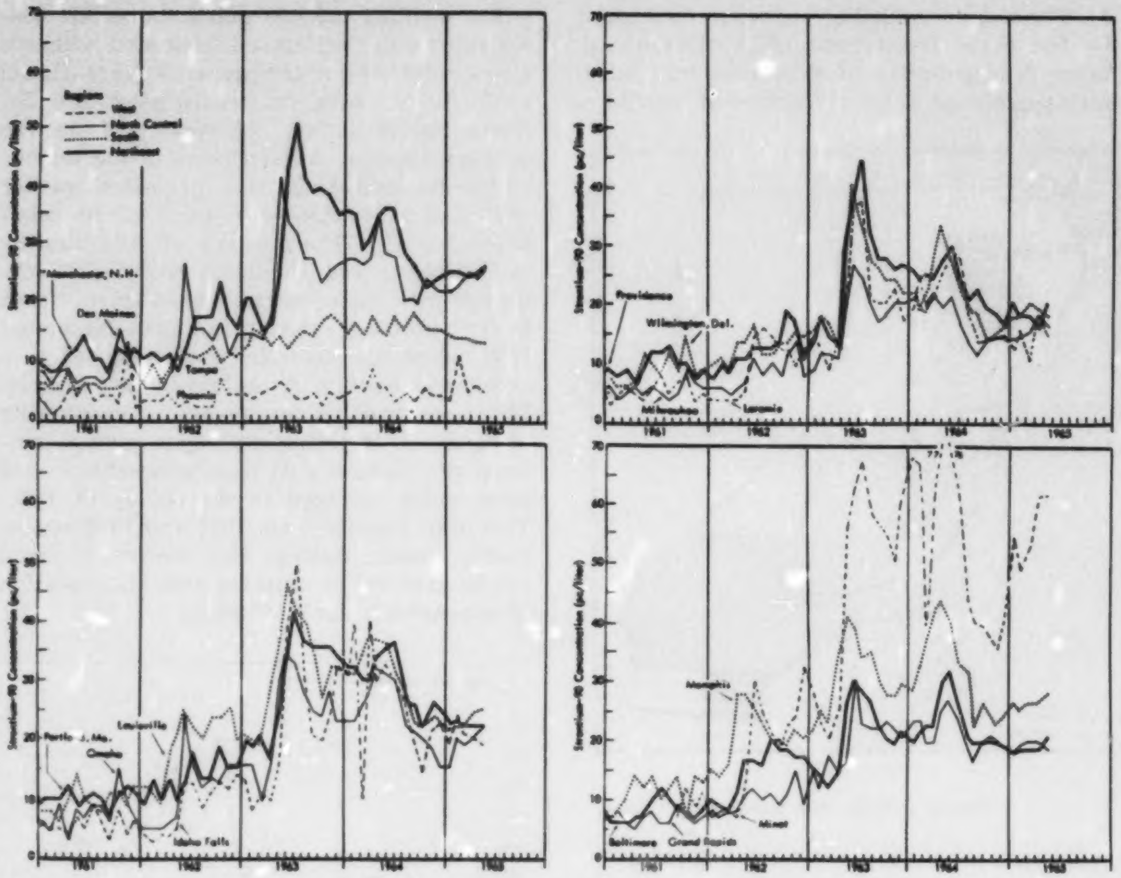

Figure 3. Strontium-90 concentrations in pasteurized milk, 1961—May 1965

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2. California Milk Network
January–March 1965

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

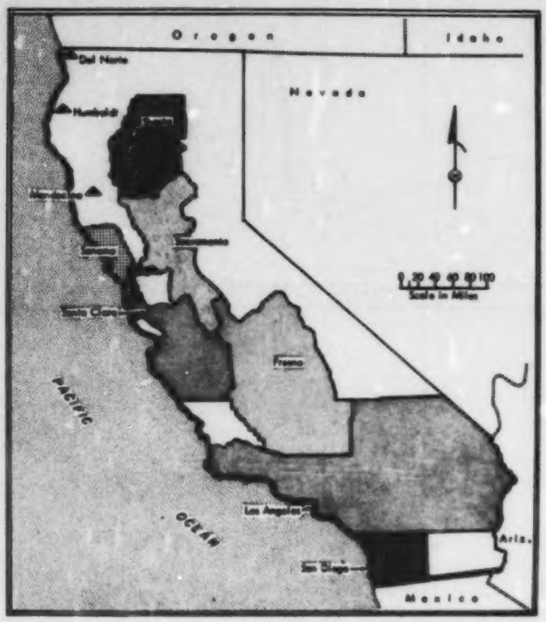

Figure 4. California milksheds

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, strontium is precipitated, scavenged, and beta counted in a low-background counter. After a two-week ingrowth period, the yttrium–90 is precipitated from the radiostrontium fraction and beta counted. Strontium–90 is determined from the yttrium–90 results; strontium–89 is determined by difference.

Potassium–40, iodine–131, cesium–137 and barium–140 in whole fluid milk are determined by gamma-scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pCi/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures has been published earlier (*4*).

Results

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 6 for the period January–March 1965. As has been previously noted the Del Norte sample differs significantly from the network average. A description of the various California milksheds was presented earlier (*5*). Radiostrontium was discussed in detail previously (*6*). The presence of strontium–89 in Del Norte and Humboldt counties is consistent with an apparent deposition of fresh fission products during October–November 1964, which was discussed previously (*6*).

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 5. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. This peak resulted from 1961 and 1962 atmospheric nuclear testing. This downward trend can be expected to continue with the cessation of atmospheric nuclear testing.

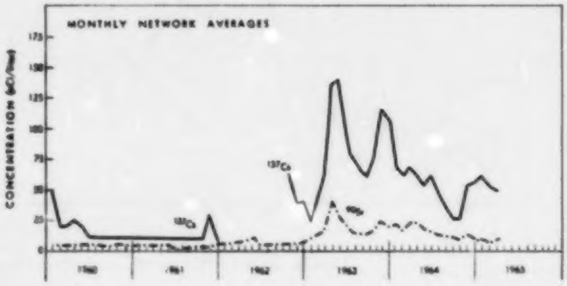

Figure 5. Radionuclides in California pasteurized milk

Table 6. Stable elements and radionuclides in California milk,[a] January–March 1965

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
January	1.34	1.31	1.23	1.12	1.15	1.25	1.19	1.17	1.38	1.10	1.22
February	1.31	1.26	1.25	1.13	1.25	1.26	1.17	1.18	1.18	1.23	1.22
March	1.34	1.20	1.21	1.17	1.12	1.26	1.16	1.20	1.18	1.18	1.20
Potassium-40 (pCi/liter)											
January	1,130	1,170	1,180	1,190	1,400	1,200	1,280	1,200	1,180	1,170	1,210
February	1,140	1,260	1,200	1,230	1,280	1,220	1,250	1,450	1,180	1,340	1,260
March	1,130	1,160	1,200	1,160	1,310	1,230	1,290	1,370	1,200	1,170	1,220
Strontium-89 (pCi/liter)											
January	17	NA	ND	NA	NA	NA	NA	NA	NA	NA	—
February	10	NA	ND	NA	NA	NA	NA	NA	NA	NA	—
March	8	NA	5.3	NA	NA	NA	NA	NA	NA	NA	—
Strontium-90 (pCi/liter)											
January	54	5.6	10.8	4.4	6.3	6.1	5.2	4.9	9.0	9.8	11.6
February	41	5.7	12.8	5.4	8.7	5.6	4.2	4.4	8.3	11.8	10.7
March	39	8.5	13.0	4.1	10.6	8.4	4.3	8.5	9.5	10.4	11.6
Cesium-137 (pCi/liter)											
January	254	33	65	26	28	37	27	24	47	41	58
February	165	37	69	33	40	36	23	38	41	26	50
March	106	38	55	27	33	42	21	37	44	60	46

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
Key to symbols: NA—indicates no analysis.
ND—indicates below detectable level.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*June 1964*
January–March 1964	*September 1964*
April–June 1964	*December 1964*
July–September 1964	*March 1965*
October–December 1964	*June 1965*

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3. Michigan Milk Network
November 1962—December 1964

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charleviox, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 6). Dairy samples within each area are composited in proportion to sales volume.

Analytical procedures

The resultant samples are analyzed weekly for strontium–90, iodine–131, cesium–137, potassium–40, and barium–lanthanum–140. The analytical procedure for strontium–90 is based upon ion exchange methods. Cations are eluted from the ion exchange resin with a sodium chloride solution. Subsequently calcium and strontium are separated using a nitric acid method. The strontium is scavenged from the rare earths and set aside for a two-week yttrium–90 ingrowth. The yttrium–90 is then separated and counted in a low-background beta counter, after which the strontium–90 is calculated.

Iodine–131, cesium–137, potassium–40, and barium–lanthanum–140 concentrations are determined by gamma-scintillation spectroscopy. The counting system consists of a 4 x 4-inch sodium iodide (thallium-activated) crystal detector and a 400–channel pulse-height analyzer.

The minimum levels of detectability are as follows: strontium–90, 9 picocuries per liter; cesium–137, 5 picocuries per liter; iodine–131, 14 picocuries per liter; potassium–40, 80 picocuries per liter; and barium–lanthanum–140, 4 picocuries per liter.

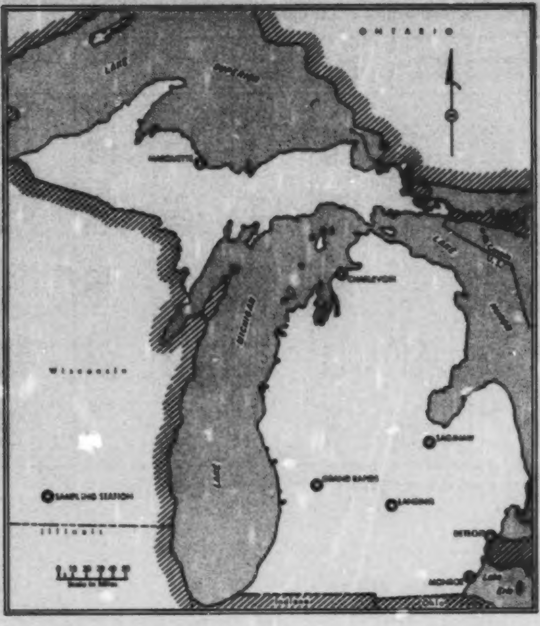

Figure 6. Michigan milk sampling stations

Results and discussion

Tables 7 through 13 present the monthly average radionuclide concentrations in Michigan pasteurized milk for the period November 1962 through December 1964. The results are given for the seven major milk producing areas in the State.

During this period iodine-131 and barium-lanthanum-140 concentrations in general remained below detectable levels.

In order to visualize general trends in strontium-90 and cesium-137, monthly average concentrations are presented graphically in figure 7. Strontium-90 and cesium-137 concentrations increased in the spring of 1963 following atmospheric nuclear testing. Strontium-90 concentrations reached a peak in the spring of 1964. Cesium-137 concentrations reached a peak in the summer of 1963 and have decreased since that time.

Table 7. Radionuclides in Charlevoix milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,210	NA	<20	96	0
February	1,360	NA	<20	73	0
March	1,320	NA	<20	82	1
April	1,300	NA	<20	81	1
May	1,320	NA	<20	83	1
June	1,260	NA	<20	148	1
July	1,280	21	<20	180	1
August	1,270	16	<20	195	2
September	1,280	20	<20	172	5
October	1,270	15	<20	146	8
November	1,260	17	<20	155	8
December	1,360	19	<20	170	3
1964					
January	1,280	20	<20	167	5
February	1,330	25	<20	166	1
March	1,290	23	<20	168	4
April	1,340	21	<20	174	2
May	1,310	24	<20	150	2
June	1,300	25	<20	153	1
July	1,300	20	<20	163	3
August	1,340	18	<20	95	1
September	1,210	18	* <14	86	2
October	NS	NS	NS	NS	NS
November	1,360	19	<14	90	0
December	1,360	NA	<14	86	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

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Table 8. Radionuclides in Detroit milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	1,240	NA	60	70	8
December	1,300	NA	24	72	1
1963					
January	1,310	NA	<20	73	0
February	1,330	NA	<20	80	0
March	1,360	NA	<20	69	5
April	1,310	NA	<20	73	0
May	1,320	NA	<20	85	1
June	1,330	NA	<20	112	2
July	1,330	14	<20	120	1
August	1,310	14	<20	145	0
September	1,280	13	<20	125	7
October	1,280	10	<20	108	3
November	1,330	11	<20	113	5
December	1,340	13	<20	125	1
1964					
January	1,310	16	<20	128	2
February	1,270	19	<20	128	2
March	1,360	18	<20	126	1
April	1,240	17	<20	123	3
May	1,280	19	<20	120	2
June	1,330	16	<20	112	1
July	1,280	17	<20	120	1
August	1,310	17	<20	74	1
September	1,200	14	* <14	55	1
October	NS	NS	NS	NS	NS
November	1,330	12	<14	60	0
December	1,360	NA	<14	67	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 9. Radionuclides in Grand Rapids milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	1,320	NA	<20	64	1
1963					
January	1,300	NA	<20	71	0
February	1,310	NA	<20	65	1
March	1,350	NA	<20	69	4
April	1,320	NA	<20	66	1
May	1,400	NA	<20	85	0
June	1,300	NA	<20	113	1
July	1,260	22	<20	139	1
August	1,300	16	<20	146	0
September	1,330	13	<20	128	4
October	1,290	13	<20	124	6
November	1,280	12	<20	125	5
December	1,330	14	<20	137	1
1964					
January	1,330	19	<20	134	3
February	1,290	18	<20	137	2
March	1,320	18	<20	139	2
April	1,310	18	<20	134	2
May	1,310	22	<20	133	0
June	1,280	21	<20	128	2
July	1,270	20	<20	118	3
August	1,350	16	<20	84	1
September	1,180	17	* <14	66	1
October	NS	NS	NS	NS	NS
November	1,370	18	<14	70	1
December	1,360	NA	<14	71	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 10. Radionuclides in Lansing milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	1,250	NA	48	61	4
December	1,300	NA	<20	61	2
1963					
January	1,350	NA	<20	61	1
February	1,390	NA	<20	57	0
March	1,310	NA	<20	61	1
April	1,350	NA	<20	59	1
May	1,300	NA	<20	81	3
June	1,310	NA	<20	107	0
July	1,290	14	<20	114	3
August	1,220	20	<20	124	6
September	1,330	12	<20	109	2
October	1,330	12	<20	99	8
November	1,300	10	<20	112	2
December	1,330	14	<20	113	5
1964					
January	1,280	15	<20	121	3
February	1,280	17	<20	118	4
March	1,330	21	<20	123	1
April	1,340	18	<20	121	2
May	1,300	19	<20	114	1
June	1,240	20	<20	108	3
July	1,310	15	<20	114	1
August	1,340	17	<20	73	1
September	1,210	15	* <14	53	1
October	NS	NS	NS	NS	NS
November	1,350	17	<14	59	1
December	1,410	NA	<14	68	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.

Key to symbols: NS—no sample collected
NA—no analyses

Table 11. Radionuclides in Marquette milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,290	NA	<20	110	3
February	1,340	NA	<20	149	0
March	NS	NS	NS	NS	NS
April	1,340	NA	<20	137	1
May	1,330	NA	<20	158	1
June	1,370	18	<20	257	0
July	1,270	14	<20	308	5
August	1,290	27	<20	311	6
September	1,250	30	<20	295	8
October	1,240	18	<20	233	6
November	1,320	28	<20	232	10
December	1,340	35	<20	254	7
1964					
January	1,350	37	<20	263	5
February	1,310	40	<20	257	7
March	1,330	43	<20	267	5
April	1,340	22	<20	274	0
May	1,330	41	<20	249	1
June	1,310	NA	<20	249	5
July	1,320	38	<20	220	6
August	1,300	33	<20	149	2
September	1,180	30	* <14	126	8
October	NS	NS	NS	NS	NS
November	1,300	NA	20	128	8
December	1,340	NA	<14	150	1

* Minimum detectable level reduced by recalibration of instrument in September 1964.

Key to symbols: NS—no sample collected
NA—no analyses

Table 12. Radionuclides in Monroe milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,260	NA	<20	50	1
February	1,280	NA	<20	53	1
March	1,320	NA	<20	54	1
April	1,320	NA	<20	55	1
May	1,310	NA	<20	63	1
June	1,330	NA	<20	86	0
July	1,290	11	<20	87	1
August	1,320	10	<20	85	2
September	1,350	7	<20	65	3
October	1,250	8	<20	69	3
November	1,310	7	<20	77	9
December	1,330	9	<20	79	1
1964					
January	1,330	15	<20	93	2
February	1,260	11	<20	84	1
March	1,370	11	<20	84	1
April	1,280	12	<20	85	1
May	1,270	14	<20	87	0
June	1,270	16	<20	102	2
July	NS	NS	NS	NS	NS
August	1,350	12	<20	56	0
September	1,230	14	* <14	43	1
October	NS	NS	NS	NS	NS
November	1,340	13	15	47	0
December	1,370	NA	<14	50	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 13. Radionuclides in Saginaw milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,240	NA	<20	64	1
February	1,240	NA	<20	71	3
March	1,370	NA	<20	68	0
April	1,300	NA	<20	60	2
May	1,320	NA	<20	71	0
June	1,330	NA	<20	109	1
July	1,330	15	<20	132	1
August	1,350	11	<20	143	3
September	1,290	13	<20	134	3
October	1,300	12	<20	122	5
November	1,280	12	<20	134	5
December	1,310	12	<20	143	2
1964					
January	1,330	15	<20	144	1
February	1,300	17	<20	144	2
March	1,290	19	<20	151	2
April	1,320	18	<30	144	0
May	1,280	18	<20	136	0
June	1,310	17	<20	125	0
July	1,330	15	<20	100	1
August	1,340	16	<20	78	0
September	1,170	13	* <14	55	1
October	NS	NS	NS	NS	NS
November	1,340	12	<20	58	0
December	1,360	NA	<14	68	0

* Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

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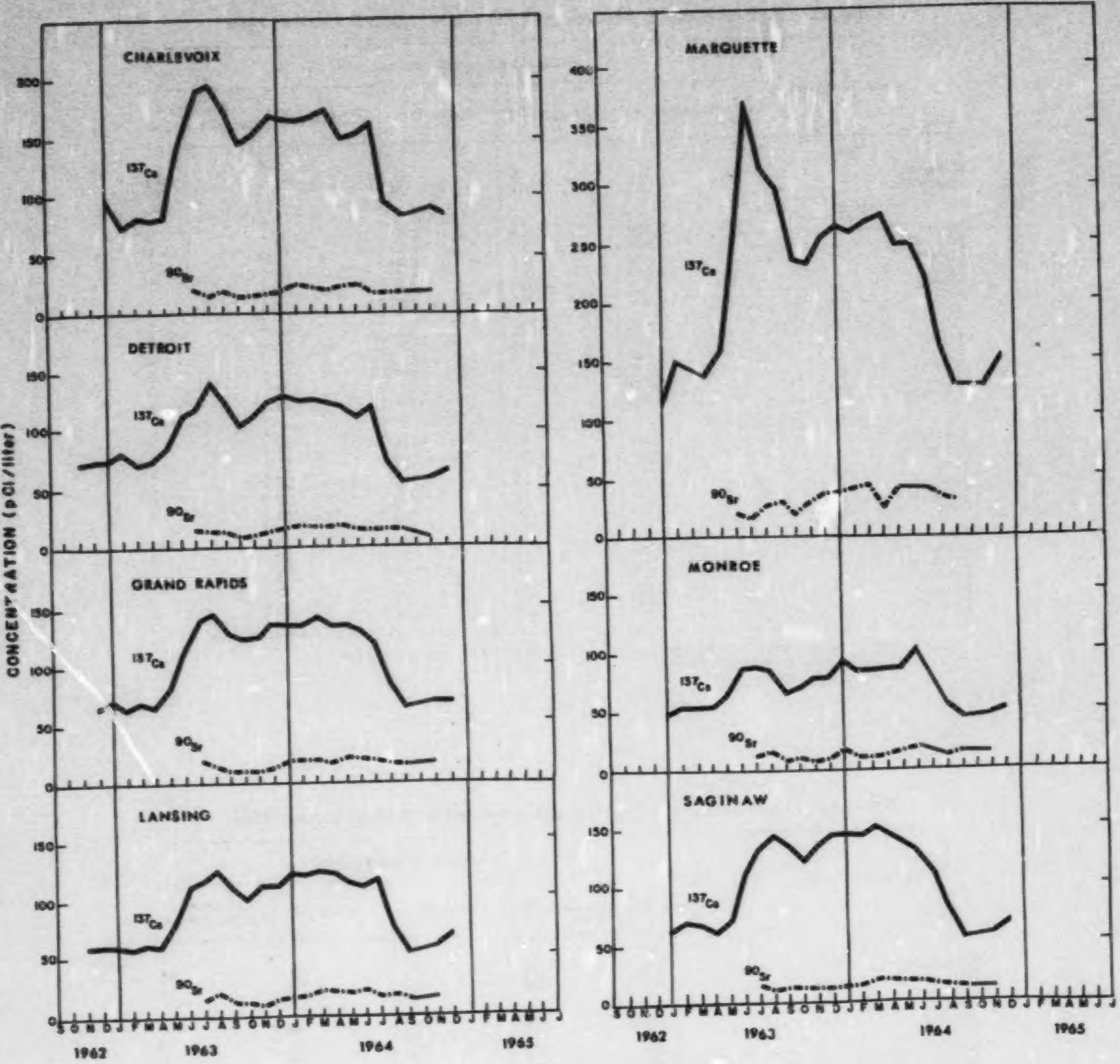

Figure 7. Monthly average concentrations of strontium-90 and cesium-137 in Michigan milk, 1962–1964

4. Pennsylvania Milk Network
January–March 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 8). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major duties supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al.* (7). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low-background proportional counter.

The January to March average strontium–90 levels in pasteurized milk are shown in table 14 and presented together with earlier network results in figure 9.

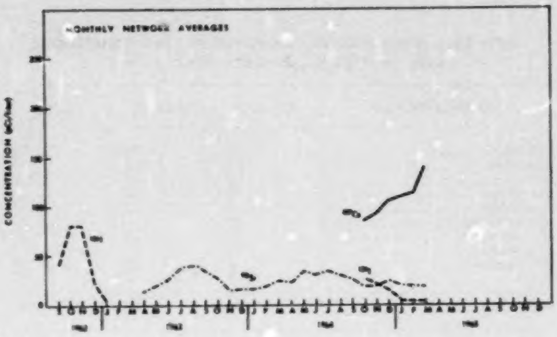

Figure 9. Radionuclide concentrations in Pennsylvania milk

Iodine–131, cesium–137 and potassium–40 concentrations are determined by gamma-scintillation spectroscopy. The resultant gamma spectra are processed using a matrix system of analysis. All iodine–131 levels were below

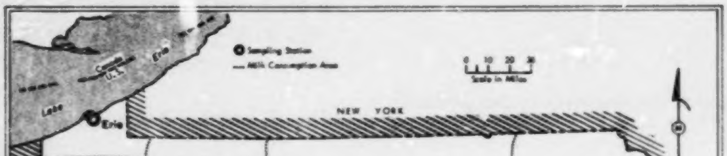
Sampling Station
Milk Consumption Area
0 10 20 30
Scale in Miles
Lake
Erie
Canada
U.S.
Erie
NEW YORK
OHIO
Williamsport
Kingston
NEW JERSEY
Pittsburgh
Altoona
Dauphin
Reading
Lancaster
York
Philadelphia
WEST VIRGINIA
MARYLAND
DEL.

Figure 8. Pennsylvania milk sampling stations and milk consumption areas

the minimum detectable concentration of 10 pCi/liter during January–March 1965. Cesium–137 and potassium–40 results are given in tables 15 and 16, respectively.

Table 14. Strontium-90 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	26	24	24
Dauphin	23	18	15
Erie	20	18	22
Kingston	20	16	18
Lancaster	23	22	17
Philadelphia	20	19	20
Pittsburgh	21	22	25
Reading	26	26	25
Williamsport	24	20	18
York	19	17	17
State average	23	20	20

Table 15. Cesium-137 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	112	107	111
Dauphin	106	101	96
Erie	143	153	172
Kingston	129	124	245
Lancaster	102	94	85
Philadelphia	95	96	173
Pittsburgh	127	126	126
Reading	124	112	121
Williamsport	92	132	137
York	95	111	121
State average	112	116	139

Table 16. Potassium-40 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	1,044	1,124	875
Dauphin	1,140	1,054	900
Erie	1,113	1,116	1,308
Kingston	1,156	1,046	1,600
Lancaster	1,088	1,150	1,000
Philadelphia	1,051	1,038	1,781
Pittsburgh	1,094	1,076	900
Reading	1,127	1,077	928
Williamsport	890	1,102	1,102
York	979	1,129	1,129
State average	1,068	1,091	1,152

Previous coverage in *Radiological Health Data:*

Period	Issue
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*
October–December 1964	*June 1965*

5. Radiostrontium in milk[3]
January–March 1965

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954 the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two diaries are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year.

Results and discussion

The calcium and strontium–90 concentrations in liquid whole milk are presented in table 17, and the strontium–90 data are plotted in figure 10. The general decreasing trend noted throughout 1964 reflects the traditional spring peak which is also apparent for January through March 1965.

The powdered milk (table 18) and powdered buttermilk (table 19) samples also displayed a spring peak in strontium–90 concentrations (figure 11). The general decreasing trend in strontium–90 levels can be expected.

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[3] Data summarized from "Fallout Program Quarterly Summary Report, HASL–161," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151. Price $4.00.

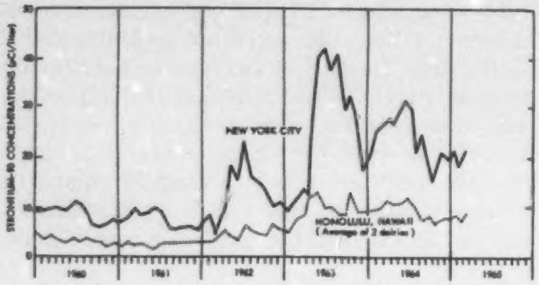

Figure 10. Strontium-90 in liquid milk samples

It is noted that strontium-90 concentrations in powdered milk and liquid whole milk are comparable when it is assumed that 0.1 kg of powdered milk is used to prepare 1 liter of liquid milk.

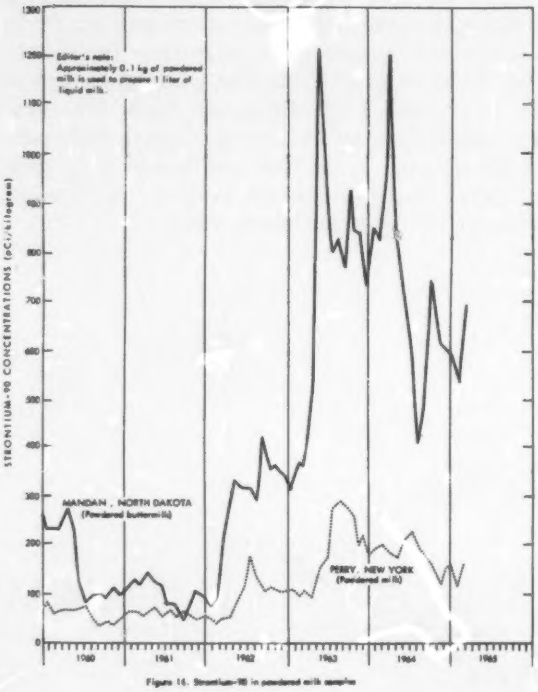

Figure 11. Strontium-90 in powdered milk samples

Table 17. Strontium-90 and calcium in liquid milk, January–March 1965

Sampling stations and periods	Calcium concentration (g/liter)	Strontium-90 concentration (pCi/liter)	Strontium-90/calcium ratio (pCi/g Ca)
New York City (averages):			
1959			11
1960			8.0
1961			6.7
1962			12
1963			26
1964			23
January 1965	1.03	21.4	20.8
February 1965	1.02	18.4	18.0
March 1965	1.01	21.4	21.1
Honolulu, Hawaii (averages):			
1959			5.0
1960			3.2
1961			2.4
1962			4.3
1963			8.0
1964			8.6
January 1965	1.04	8.2	7.9
February 1965	1.02	7.8	7.6
March 1965	1.00	8.8	8.9

Table 18. Strontium-90 and calcium in powdered milk, January–March 1965

Sampling station and periods	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/calcium ratio (pCi/g Ca)
Perry, N.Y. (averages):			
1959			8.0
1960			6.5
1961			6.2
1962			11.1
1963			21.6
1964			20.4
January 1965	9.33	166	17.7
February 1965	8.51	121	14.2
March 1965	8.73	166	19.0

Table 19. Strontium-90 and calcium in powdered buttermilk, January–March 1965

Sampling station and periods	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/calcium ratio (pCi/g Ca)
Mandan, N. Dak. (averages):			
1959			26
1960			15
1961			9.4
1962			25
1963			58
1964			62.7
January 1965	10.8	594	54.6
February 1965	10.4	522	50.0
March 1965	10.8	699	61.8

Recent coverage in *Radiological Health Data:*

Period	Issue
April–June 1963	*January 1964*
July–September 1963	*April 1964*
October–December 1963	*July 1964*
January–December 1964	*June 1965*

6. Canadian Milk Network[4]
May 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (figure 12) can be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine-131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle-furnace at 450 degrees C., and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low-background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

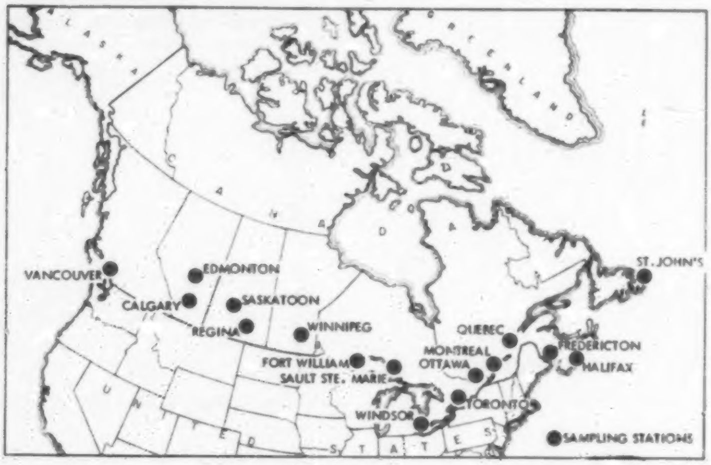

Figure 12. Canadian milk sampling stations

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[4] This report was prepared from information and data in the June 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the gamma spectrometric determination of cesium-137, no recovery factor is involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 20.

Table 20. Total error for various radionuclide concentrations in milk [a]

Radionuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	25%	20%	15%
Strontium-90	15%	10%	10%
Iodine-131	50%	20%	10%
Cesium-137	60%	20%	10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 21 presents monthly averages of strontium-90, cesium-137, stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 21. Stable elemements and radionuclides in Canadian whole milk, May 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (μCi/liter)
Calgary	1.14	1.5	29.8	98
Edmonton	1.04	1.5	25.7	91
Ft. William	1.02	1.7	40.9	182
Fredericton	1.15	1.6	33.9	176
Halifax	1.15	1.6	38.1	218
Montreal	1.13	1.6	28.6	144
Ottawa	1.16	1.6	18.0	89
Quebec	1.12	1.6	36.1	229
Regina	1.17	1.6	34.5	102
St. John's, Nfld	1.14	1.6	35.5	178
Saskatoon	1.15	1.6	37.6	89
Sault Ste. Marie	1.13	1.6	37.4	153
Toronto	1.10	1.6	13.3	76
Vancouver	1.14	1.6	35.2	164
Windsor	1.15	1.6	11.0	78
Winnipeg	1.08	1.6	31.8	123
Average	1.12	1.6	30.5	137

7. Pan American Milk Sampling Program May 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine-131 and cesium-137 are determined by gamma-scintillation spectrometry. Strontium-89, strontium-90, and barium-140 are determined radiochemically (*9*). Analytical errors are discussed in the "Analytical Procedures, Pasteurized Milk Network."

Data presentation

Table 2 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations. The monthly average of iodine-131 and barium-140 concentrations in milk was less than 10 pCi/liter except for Caracas, Venezuela, where a concentration of 20 pCi/liter for iodine-131 was observed.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 22. Stable element and radionuclide concentrations in milk, PAHO, May 1965

Sampling station	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
	(g/liter)	(g/liter)	(pCi/liter)	(pCi/liter)	(pCi/liter)
Canal Zone: Cristobal	1.08	—	<5	4	35
Jamaica: Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.19	1.46	<5	19	365
Puerto Rico: San Juan	1.09	—	<5	12	45
Venezuela: Caracas[a]	1.10	1.60	<5	5	30

[a] May 1965 iodine-131 concentrations in milk were 20 pCi/liter.
Symbol: NS-no sample collected

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, MAY 1964–MAY 1965

Division of Radiological Health
Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake–dose and dose–biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunc- proximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3*, *4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 gram daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of nonmilk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk for the twelve month periods,[a] May 1964–April 1965 and June 1964–May 1965, pCi/liter

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965
Ala:	Montgomery	3	3	21	20	0	0	66	58
Alaska:	Palmer	3	3	20	19	0	1	98	85
Ariz:	Phoenix	3	3	5	5	0	0	25	24
Ark:	Little Rock	3	3	40	37	1	1	86	74
Calif:	Sacramento	3	3	7	7	0	1	31	33
	San Francisco	3	3	8	8	0	0	36	35
C. Z:	Cristobal	3	3	5	5	0	0	47	45
Colo:	Denver	3	3	19	19	0	0	81	80
Conn:	Hartford	3	3	18	18	0	0	106	98
Del:	Wilmington	3	3	21	19	1	1	89	81
D. C:	Washington	3	3	19	18	0	1	64	59
Fla:	Tampa	3	3	15	14	0	0	217	208
Ga:	Atlanta	3	3	28	27	0	0	106	96
Hawaii:	Honolulu	3	3	12	11	0	0	72	70
Idaho:	Idaho Falls	3	3	23	22	0	0	117	108
Ill:	Chicago	3	3	18	18	0	0	91	86
Ind:	Indianapolis	3	3	19	18	1	1	75	70
Iowa:	Des Moines	3	3	24	23	0	3	68	64
Kans:	Wichita	3	3	20	19	0	0	54	50
Ky:	Louisville	3	3	26	25	0	0	59	54
La:	New Orleans	4	4	46	44	0	0	105	94
Maine:	Portland	3	3	26	25	1	1	161	152
Md:	Baltimore	3	3	21	20	0	0	72	65
Mass:	Boston	3	3	28	26	0	0	164	154
Mich:	Detroit	3	3	17	17	2	2	90	85
	Grand Rapids	3	3	20	19	1	1	99	94
Minn:	Minneapolis	4	4	28	27	0	1	105	99
Miss:	Jackson	3	3	37	35	0	0	76	67
Mo:	Kansas City	4	3	25	23	0	4	58	54
	St. Louis	3	3	20	19	0	1	58	54
Mont:	Helena	3	3	21	19	1	3	114	103
Nebr:	Omaha	3	3	23	22	0	1	68	63
Nev:	Las Vegas	3	3	8	8	1	1	54	50
N. H:	Manchester	3	3	27	26	1	1	183	172
N. J:	Trenton	3	3	18	17	1	1	89	82
N. Mex:	Albuquerque	2	2	11	10	1	1	47	45
N. Y:	Buffalo	3	3	18	18	0	0	112	107
	New York	3	3	23	22	1	1	117	110
	Syracuse[b]	3	3	17	16	0	0	103	94
N. C:	Charlotte	3	3	35	34	0	0	88	79
N. Dak:	Minot	7	5	53	51	0	0	134	129
Ohio:	Cincinnati	3	3	19	18	0	0	69	64
	Cleveland	3	3	20	19	0	1	94	89
Okla:	Oklahoma City	3	3	21	20	0	0	54	51
Ore:	Portland	4	4	27	25	0	0	128	121
Pa:	Philadelphia	3	3	19	18	0	0	87	79
	Pittsburgh	3	3	27	27	0	0	117	110
P. R:	San Juan	3	3	12	12	0	0	62	58
R. I:	Providence	3	3	21	20	0	0	123	116
S. C:	Charleston	3	3	31	30	0	0	107	100
S. Dak:	Rapid City	4	4	36	34	0	0	130	126
Tenn:	Chattanooga	3	3	36	34	0	0	85	76
	Memphis	3	3	29	28	0	0	54	48
Tex:	Austin	3	3	8	8	0	0	33	31
	Dallas	3	3	18	18	0	0	47	44
Utah:	Salt Lake City	5	3	25	24	0	0	136	131
Vt:	Burlington	3	3	24	23	2	2	133	125
Va:	Norfolk	3	3	18	17	0	1	74	68
Wash:	Seattle	5	4	27	25	0	0	133	127
	Spokane	4	3	26	26	0	0	116	110
W. Va:	Charleston	3	3	22	20	0	1	55	49
Wis:	Milwaukee	3	3	16	15	1	2	101	96
Wyo:	Laramie	4	4	18	17	0	0	86	82
Network average		3	3	22.0	21.1	0	1	91	85

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <2 pCi/liter.

[b] Annual averages were computed on basis of 48 weekly averages.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12 month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS, JULY-OCTOBER 1964

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other source. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Bureau of Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of the regular meals (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations.

The radiochemical analyses are based upon three basic procedures: chemical separation of strontium, analysis of radium-226, and gamma spectral analysis of a gallon of the wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 1 and 2 for July through October 1964.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

Table 1. Estimated daily intake of radionuclides in California diets,[a] July–August 1964

City	Kg per capita per day[b]	pCi/capita/day							Grams/capita/day			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable Sr
Bakersfield	2.1	0	22	0.8	34	29	0	8	2.9	3.5	1.0	.003
Berkeley	2.4	0	18	0	49	32	7	61	2.6	4.0	0.8	.003
Bishop	1.6	4	14	0.4	50	27	0	0	2.4	2.6	0.8	.002
Brawley	2.3	0	28	2.4	39	33	0	21	3.5	4.4	1.1	.002
Crescent City	2.3	0	28	0.4	125	55	4	13	2.5	3.9	0.9	.003
Eureka	2.0	0	8	0.4	50	30	2	42	2.6	3.0	1.0	.003
Fresno	2.4	0	49	0	70	19	0	75	2.9	4.2	1.0	.004
Los Angeles	2.7	0	10	0.1	47	61	3	25	2.9	3.4	0.9	.003
Needles	1.1	0	12	0.2	33	18	1	20	1.6	2.9	0.4	.002
Quincy	1.8	0	62	1.1	41	28	0	36	2.3	2.5	0.6	.002
Redding	2.1	0	29	0.5	47	27	0	2	2.7	4.1	1.0	.004
Sacramento	2.7	0	25	0.5	44	27	0	34	3.1	5.3	1.4	.004
Salinas	2.1	0	14	0.2	50	26	0	27	2.7	3.4	0.8	.003
San Bernardino	1.9	0	29	0.2	16	25	0	0	2.7	3.3	0.9	.003
San Diego	2.0	0	5	0.2	42	28	0	31	2.7	3.2	0.8	.003
San Luis Obispo	1.3	0	18	0.4	32	18	2	25	1.9	2.8	0.6	.003
Santa Barbara	2.1	0	27	0.3	55	33	0	46	3.1	3.4	1.2	.003
Santa Rosa	2.5	0	17	0.4	43	34	0	19	3.3	4.5	1.2	.004
Susanville	2.2	0	12	0.1	72	38	0	47	3.0	4.8	0.9	.004
Ukiah	2.1	0	26	0.2	64	26	0	44	2.3	2.5	1.0	.003

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive ^{40}K.

Table 2. Estimated daily intake of radionuclides in California diets,[a] September–October, 1964

City	Kg per capita per day[b]	pCi/capita/day							Grams/capita/day			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable Sr
Bakersfield	2.4	0	16	1.2	23	30	0	0	3.1	3.5	1.2	.002
Berkeley	2.2	0	28	1.6	53	31	0	26	2.9	3.2	1.2	.002
Bishop	1.6	0	13	0.8	55	0	[d] —	0	1.8	2.1	0.7	.001
Brawley	2.6	0	9	0.8	28	0	—	0	2.1	2.4	0.7	.001
Crescent City	2.1	0	47	4.0	90	44	0	0	3.0	4.0	1.0	.002
Eureka	2.4	0	20	2.0	66	57	0	0	3.1	3.5	1.4	.002
Fresno	2.6	0	28	2.4	50	42	[e] 0.8	0	3.2	4.6	1.3	.002
Los Angeles	2.6	0	27	1.6	110	65	—	0	2.8	3.3	0.7	.002
Needles	1.9	0	33	2.9	47	31	0	0	2.7	2.9	0.8	.002
Quincy	1.9	0	9	1.2	52	28	0	0	2.9	2.9	0.6	.002
Redding	2.2	0	11	2.2	49	31	0	0	3.4	4.8	1.3	.002
Sacramento	2.7	0	17	4.4	81	[e] 13	—	[e] 6	3.4	5.4	1.3	.002
Salinas	2.5	0	12	3.0	47	0	—	36	3.4	3.8	0.9	.002
San Bernardino	2.2	0	11	2.1	82	32	—	0	3.6	3.5	1.2	.002
San Diego	2.2	0	10	1.6	78	42	—	0	3.2	3.4	0.8	.002
San Luis Obispo	1.4	0	12	0.7	45	29	0	0	1.8	2.8	0.6	.001
Santa Barbara	1.8	0	14	2.6	36	30	0	0	3.1	3.4	0.8	.002
Santa Rosa	2.4	0	12	2.8	117	44	—	0	3.0	3.2	1.2	.002
Susanville	1.9	0	33	1.6	—	—	—	—	2.7	3.0	0.8	.002
Ukiah												

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive ^{40}K.
[d] Dash indicates sample lost in laboratory procedures.
[e] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant. Where no value is given, no activity was detected.

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STRONTIUM-90 IN TRI-CITY DIETS NOVEMBER 1964–JANUARY 1965[1]

Health and Safety Laboratory Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities about every 3 months and are analyzed for strontium–90. Using data from the U.S. Department of Agriculture (*1*), the annual consumption by an average individual in the same 19 food categories can be estimated. The annual dietary intake of strontium–90 can be estimated by summing the contributions from each category.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the November 1964—January 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The previously noted geographic distribution pattern of strontium–90 in the diet is seen to persist as it has since the initial samplings in 1960. Levels have been highest in New York City and lowest in San Francisco. In New York

Table 1. Average per person dietary consumption and strontium-90 intake, November 1964–January 1965 sampling

Food category	Average U.S. consumption		Strontium-90 intake					
			New York City November 1964		Chicago January 1965		San Francisco December 1964	
	Diet (kg/yr)	Calcium (g/yr)	pCi/kg [a]	pCi/yr	pCi/kg [a]	pCi/yr	pCi/kg [a]	pCi/yr
[illegible]	37	37.0	24.6±1.0	910	21.0±0.8	777	13.0±1.0	481
[illegible] products	11	10.0	75.4±2.5	829	47.5±1.4	522	26.8±1.0	295
Eggs	16	9.1	4.0±0.1	64	5.2±0.1	83	5.5±0.1	88
Fresh vegetables	43	15.0	23.2±0.7	998	8.7±0.4	374	2.9±0.3	125
Root vegetables	17	6.1	14.6±0.5	248	11.4±0.4	194	8.4±0.3	143
Milk	221	234.3	20.6±1.6	4,508	9.3±0.3	2,060	7.2±0.3	1,591
Poultry	17	9.2	3.5±0.1	59	1.5±0.1	26	1.1±0.1	18
Fresh fish	8	10.8	1.6±0.1	13	1.6±0.1	13	0.4±0.1	3
Flour	43	8.6	30.4±0.5	1,307	17.0±0.2	731	6.4±0.2	275
Macaroni	3	0.7	16.9±0.5	51	17.0±0.8	51	9.9±0.3	30
Rice	3	1.1	0.6±0.2	2	10.1±0.3	30	3.3±0.2	10
Meat	73	10.9	4.0±0.2	292	2.3±0.1	168	1.8±0.1	131
Shellfish	1	0.8	6.9±0.2	7	1.1±1.1	1	1.9±0.2	2
Dried beans	3	2.9	21.7±1.4	65	26.9±1.5	80	19.8±1.6	59
Fresh fruit	68	12.6	11.4±0.3	775	20.3±0.4	1,380	3.8±0.2	258
Potatoes	45	5.8	9.5±0.1	428	8.6±0.5	387	4.4±0.3	198
Canned fruit	26	1.3	2.6±0.8	68	3.9±0.1	101	1.9±0.1	49
Fruit juices	19	1.7	3.8±0.2	72	5.5±0.3	104	2.8±0.2	53
Canned vegetables	20	4.2	7.9±0.6	158	1.3±0.5	26	5.0±0.3	100
Annual intake	674	383		10,854		7,108		3,900
pCi ^{90}Sr/g Ca in total diet			28.3		18.6		10.2	

[a] Error terms are one standard deviation (due to counting).

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[1] Data from Fallout Program Quarterly Summary Report, HASL—161:213–215 (July 1, 1965).

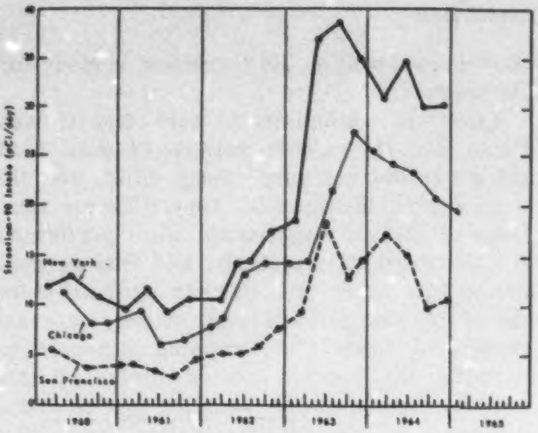

Figure 1. Strontium–90 daily intake in Tri-City diet study

City and Chicago the strontium–90 intake is observed to decrease with respect to the previous sampling period three months earlier. The San Francisco strontium–90 intake is observed to increase slightly. Due in part to its high annual consumption, milk continues to be the predominant source of strontium–90 in the diet.

A discussion of cesium–137 intakes as reflected in the Tri-City Diet Study is presented elsewhere (*4*).

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Period	Issue
Sixteenth Sampling (February 1964—April 1964)	*December 1964*
Seventeenth Sampling (July–September 1964)	*March 1965*
Eigtheenth Sampling (August–October 1964)	*June 1965*

DIETARY INTAKES AND BODY BURDENS OF CESIUM-137[1]

Joseph Rivera[2]

Cesium–137 concentrations in foods purchased in New York City, Chicago, and San Francisco during the last quarter of 1964 were determined radiochemically (*1*). The results of these analyses are shown in table 1.

Since the foods were ashed at 482° C for 24 hours prior to analysis, it is known that some cesium–137 losses must have occurred due to volatilization. Preliminary experiments comparing the activities in wet and dry ashed aliquots of milk, flour, and meat indicate that these losses are about 20 percent. In view of these findings, the daily intakes of cesium–137 calculated from the concentrations of cesium–137 found were increased by 20 percent. These estimates of daily intakes, along with similar estimates based on the analyses of foods purchased at the three cities during the last quarters of 1962 and 1963, are shown graphically in figure 1.

Although estimates of cesium–137 intake were made at each city only at the end of each year, an indication of how well the results represent the intake for the entire year may be deduced by comparing the observed cesium–137 body burdens of people with body burdens calculated using the estimated daily intakes.

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[1] Taken from the Atomic Energy Commission's *Fallout Program Quarterly Summary Report, HASL–158*:306–309. Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 (April 1, 1965). Price $4.00.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division of the Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, New York 10014.

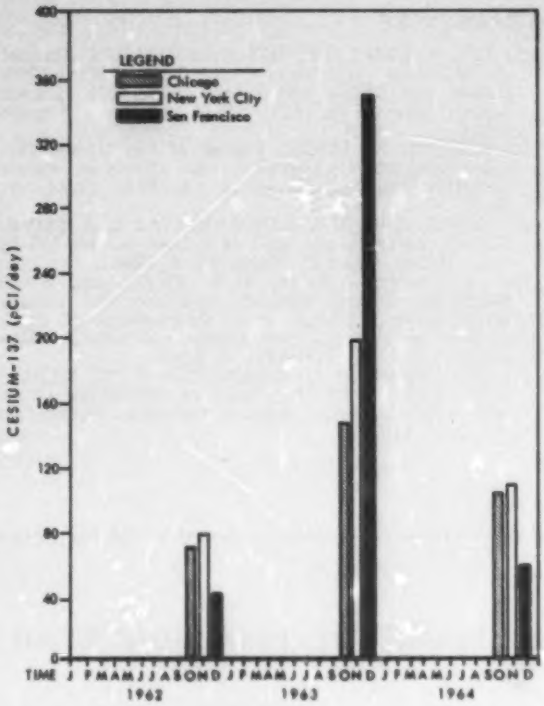

Figure 2. Estimated daily intake of cesium-137 in Tri-City diets

It has been found that in adult man close to 100 percent of ingested cesium-137 is absorbed, and that the long-term retention of the cesium-137 is described reasonably well by a single exponential, with a biological half-life of 100 days (2).

The body burden of cesium-137 resulting from ingestion of cesium-137 can therefore be given by:

$$Q(t) = Q_0\,(t)\,e^{-0.693t/100} + \frac{P(100)}{0.693}(1 - e^{-0.693t/100})$$

where "Q" is the body burden in pCi resulting from the ingestion of "P" pCi/day of cesium-137 for "t" days, and "Q_o" is the body burden at time zero.

From the date of Cohn, *et al.* (*3*) and Gustafson, *et al.* (*4*), it is estimated that at the beginning of 1962 the body burdens of New York and Chicago residents were about 30 pCi/g K. Assuming a potassium content of standard man of 140 g (*5*), calculations from the diet values of the cesium-137 body burdens of New York and Chicago residents were possible. The results, along with observed levels of cesium-137 for New York and Chicago residents determined by whole body counting, are shown in table 2. Similar data on the body burdens of cesium-137 for San Francisco residents were not available; therefore, calculations for this site could not be made.

The agreement between observed and calculated results is surprisingly good and suggests that the diet estimates are reasonable. It is expected that more quantitative estimates of the cesium-137 losses incurred during the ashing of foods will soon be available. With this information and perhaps a more frequent sampling of foods during 1965, accurate predictions of the average adult body burdens of cesium-137 that will exist in 1966 should be possible.

Table 1. Cesium-137 in Tri-City diets, 1964 sampling

Food category	kg/yr	New York City, November 1964		Chicago, October 1964		San Francisco, December 1964	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Bakery products	37	48.3	1,787	52	1,924	14.0	518
Whole grain products	11	120.0	1,320	104	1,144	11.0	121
Eggs	16	11.4	182	17	272	12.8	205
Fresh vegetables	43	3.0	129	7.2	310	65.8	2,829
Root vegetables	17	5.0	85	1.1	19	9.1	155
Milk	221	55	12,155	42	9,282	23	5,083
Poultry	17	21.0	357	42	714	5.0	85
Fresh fish	8	15.1	121	203	1,624	6.7	54
Flour	43	60.3	2,593	81	3,483	7.2	310
Macaroni	3	126.6	362	162	486	72.0	216
Rice	3	32.6	98	67	201	46.4	139
Meat	73	117.9	8,607	101	7,373	20.1	1,467
Shellfish	1	12.7	13	8.1	8	6.3	6
Dried beans	3	218.7	656	47	141	6.8	20
Fresh fruit	68	16.1	1,095	13	884	44.6	3,033
Potatoes	45	17.0	765	8.7	392	38.5	1,733
Canned fruit	26	10.7	273	28	728	24.5	637
Fruit juices	19	32.4	616	28	532	4.1	78
Canned vegetables	20	4.9	98	19	380	6.1	122
pCi/yr			31,311		29,897		16,811
pCi/day [a]			101.3		102.4		57.6

[a] Corrected for loss in ashing.

Table 2. Cesium-137 intakes and body burdens

Year and location	Average daily intake, P, during year (pCi/day)	Body burdens at end of year (pCi/g K)	
		Calculated	Observed
1962			
New York	78	74	55
Chicago	71	67	54
1963			
New York	196	185	140
Chicago	145	138	112
1964			
New York	106	102	110
Chicago	102	97	~90

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STRONTIUM-90 IN CANADIAN WHEAT FROM THE 1963 CROP YEAR[1]

E. R. Samuels[2]

The measurement of strontium-90 in Canadian wheat was started in 1959 by the Radiation Protection Division as a part of its nationwide fallout study program. Prior to this, the analyses were carried out by Atomic Energy of Canada, Limited. Since wheat and wheat flour are important cereal products in Canada, this project was undertaken to obtain some measure of the possible contribution of these products to the population's intake of strontium-90 and at the same time provide some information as to the mode of entry of fallout radionuclides into the wheat grain.

This report presents the results of measurements made on Canadian hard red spring wheat grown and harvested during 1963. Data for previous crop years have already been published (*1–3*).

Sampling and analytical procedures

Composite samples of wheat are obtained annually from nine sampling districts representing the major wheat growing areas of Canada (figure 1). Sampling is carried out in such a manner that the final composite samples are fully representative of the particular crop year. The samples for a given year are received at the Radiation Protection Laboratory by the spring of the following

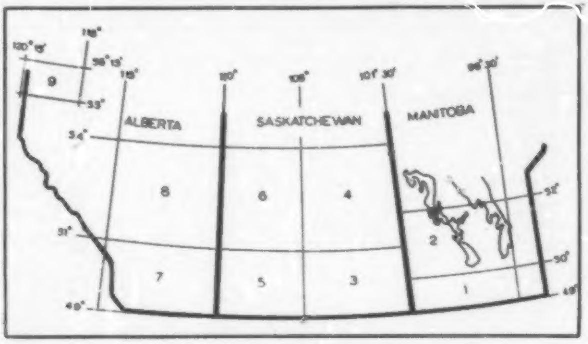

Figure 1. Wheat sampling districts of Canada

year. Details of sampling and analytical procedures have been reported in previous publications (*1–3*).

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[1] Taken from *Data From Radiation Protection Programs*, 3:3–8 (April 1965).

[2] Dr. Samuels is Chemist-in-Charge, Analytical Laboratories, Radiation Protection Division, Department of National Health and Welfare, Brookfield Road, Ottawa 8, Canada.

Results and discussion

The results of the determination of strontium–90 and stable calcium in wheat from the 1963 crop year are given in table 1. These values are the result of at least duplicate determinations.

Table 1. Strontium-90 in Canadian hard red spring wheat, crop year 1963

District	Production in millions of bushels	Calcium g/kg wheat	Strontium-90	
			pCi/kg wheat	pCi/g Ca
1	31.1	0.32	143	447
2	19.0	0.31	178	574
3	125.5	0.31	196	632
4	109.9	0.33	211	639
5	64.2	0.36	184	511
6	122.6	0.34	259	762
7	33.4	0.44	210	477
8	95.3	0.36	315	875
9	3.9	0.37	217	581
Averages (weighted for production)		0.35	227	665

The overall average strontium–90 values (weighted for production) for 1963, together with values obtained for previous years, are presented graphically in figures 2 and 3. Data are expressed as picocuries per kilogram wheat (pCi/kg wheat) and picocuries per gram calcium (pCi/g Ca), respectively.

The results in table 1 show significant variations in the strontium–90 levels of wheat grown in the different geographical areas. The lowest levels were found in Manitoba (Districts 1 and 2) and the highest levels in Central Alberta (District 8). The levels of strontium–90 were on the whole highest in the northern areas (51°–54° N) with the southern areas (49°–51° N) showing appreciably lower values. The observations are consistent with data reported for previous years (*1–3*).

The average concentration of strontium–90 in Canadian wheat grown during 1963 increased by a factor of about 3 over that observed in 1962. Similar results have been reported for 1963 U.S. wheat (*4,5*). It should be noted, however, that the concentrations reported are for the whole wheat grain and not for wheat flour. Studies on wheat and milling products (*3–5*) have clearly demonstrated that most of the strontium–90 is concentrated in the bran fraction with a relatively small amount being found in patent flour. Grummitt (*3*) found that flour contained 10 percent of the strontium–90 content of whole wheat while 76 percent was found in the bran fraction. The recent work of Pfeifer, *et al.* (*6*) on milling products from a 1963 Illinois wheat produced results in agreement with Grummitt's findings. The use of patent flour should therefore contribute very little to the population's intake of strontium–90.

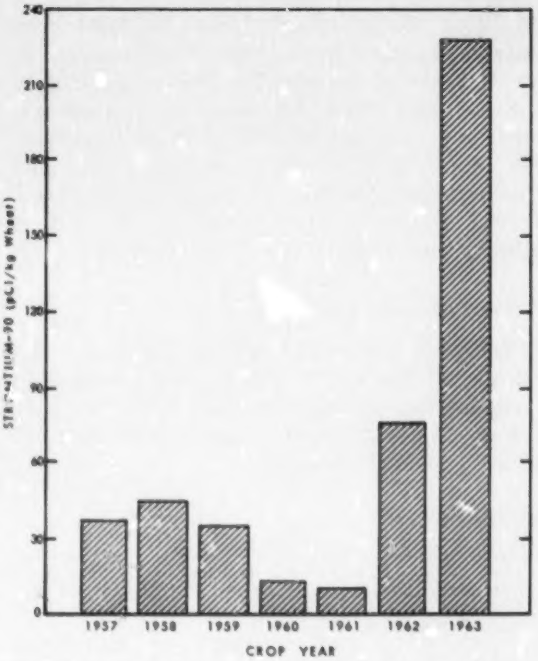

Figure 2. Strontium–90 in Canadian wheat, 1957–1963 (pCi/kg wheat)

It has been well established that strontium–90 enters the wheat grain either through root uptake from the soil or through direct deposition of fallout on the foliar surfaces. Results of analyses on wheat through the years (*1,7*) seem to suggest that direct deposition of fallout on the growing plant is the more important source of contamination during periods of heavy fallout. Taniguchi (*1*) reported a significant decrease in the strontium–90 levels of Canadian wheat from 1959 through 1961 in spite of the fact that there was a gradual increase in the cumulative deposit of strontium–

90 in the soil. This decrease is clearly shown in figure 2. Furthermore, the degree of contamination of wheat by direct deposition on the above ground parts of the plant is most likely determined by the fallout rate after emergence of the wheat ears (*8*). The marked increase in strontium-90 concentration of 1963 wheat can therefore be largely attributed to the extensive atmospheric testing which was conducted in late 1962, since this testing would result in heavy deposition of fallout during the growing period of the wheat plants in 1963.

Based on these observations, the level of strontium-90 in wheat from the 1964 crop year is expected to decrease substantially below the results obtained for 1963 wheat due to the fact that there has been no atmospheric nuclear testing subsequent to 1962, except for the small Chinese test in October 1964, and this occurred after harvesting of the 1964 crop. In the absence of further testing, the pattern observed up to 1961 should be repeated.

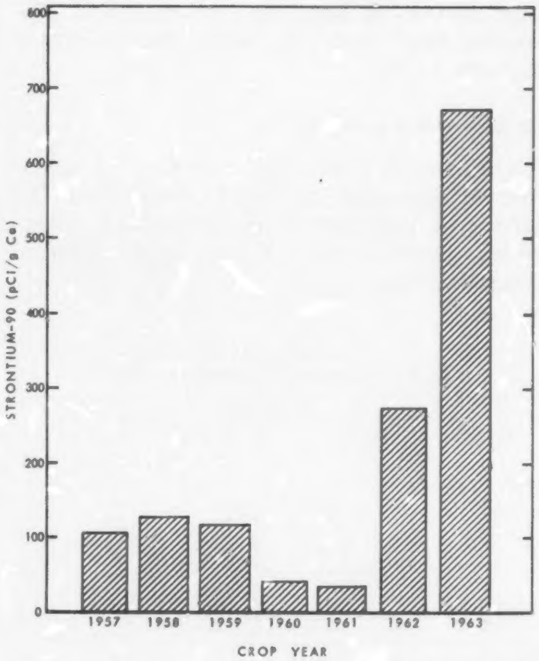

Figure 3. Strontium-90 in Canadian wheat, 1957–1963 (pCi/g Ca)

Acknowledgements

The continued assistance of the Grain Research Laboratory, Winnipeg, in providing the samples for analysis is gratefully acknowledged. The analyses were performed by J. M. Quinn and M. E. Lescot.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1965

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*9*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed for each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location, the first stations listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

Table 1. Radioactivity in raw surface waters, March 1965

Station	Beta activity, pCi/liter			Alpha activity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	32	15	47	13	4	17
Arkansas River:						
Coolidge, Kans	12	39	51	2	27	29
Ponca City, Okla	27	20	47	8	6	14
Atchafalaya River:						
Morgan City, La	219	11	230	130	1	131
Bear River:						
Preston, Idaho	0	13	13	0	3	3
Big Horn River:						
Hardin, Mont	5	20	25	1	12	13
Chena River:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	1	4	5	<1	0	<1
Clinch River:						
Clinton, Tenn	1	4	5	0	0	0
Kingston, Tenn	6	48	54	0	0	0
Colorado River:						
Loma, Colo	34	24	58	10	8	18
Page, Ariz	1	28	29	0	9	9
Parker Dam, Calif-Ariz	1	18	19	0	6	6
Columbia River:						
Wenatchee, Wash	1	6	7	0	1	1
Pasco, Wash	77	309	386	<1	<1	<1
Clatskanie, Ore	26	81	107	0	1	1
Connecticut River:						
Enfield Dam, Conn	1	4	5	0	0	0
Coosa River:						
Rome, Ga	10	5	15	2	0	2
Cumberland River:						
Cheatham Lock, Tenn	2	5	7	0	0	0
Delaware River:						
Philadelphia, Pa	4	6	10	1	0	1
Great Lakes:						
Duluth, Minn	0	2	2	0	0	0
Green River:						
Dutch John, Utah	1	18	19	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	2	9	11	0	0	0
Kansas River:						
De Soto, Kans	123	18	141	30	3	33
Klamath River:						
Keno, Oreg	3	9	12	0	<1	<1
Maumee River:						
Toledo, Ohio	9	12	21	2	2	4
Mississippi River:						
St. Paul, Minn	1	19	20	0	3	3
E. St. Louis, Ill	28	16	44	5	1	6
New Roads, La	14	9	23	8	0	8
New Orleans, La	19	11	30	7	1	8
Missouri River:						
Williston, N. Dak	4	21	25	0	6	6
Bismarck, N. Dak	1	22	23	0	5	5
St. Joseph, Mo	85	24	109	36	3	39
North Platte River:						
Henry, Nebr	2	35	37	0	32	32
Ohio River:						
Cairo, Ill	13	8	21	4	0	4
Toronto, Ohio	2	6	8	0	<1	<1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	4	5	0	1	1
Platte River:						
Plattsmouth, Nebr	85	19	104	26	2	28
Potomac River:						
Washington, D.C.	4	6	10	1	0	1
Rainy River:						
Baudette, Minn	1	17	18	0	0	0
Red River, North:						
Grand Forks, N. Dak	0	23	23	0	1	1
Red River, South:						
Alexandria, La	23	11	34	4	1	5
Rio Grande:						
El Paso, Tex	3	18	21	0	7	7
Laredo, Tex	3	11	14	0	3	3
San Joaquin River:						
Vernalis, Calif	4	6	10	1	2	3
San Juan River:						
Shiprock, N. Mex	92	17	109	38	5	43
Savannah River:						
Port Wentworth, Ga	3	7	10	<1	0	<1
Snake River:						
Wawawai, Wash	1	7	8	0	2	2
Payette, Idaho	3	10	13	0	2	2
South Platte River:						
Julesburg, Colo	9	61	70	2	56	58
Tennessee River:						
Chattanooga, Tenn	2	7	9	0	0	0
Wabash River:						
New Harmony, Ind	8	10	18	2	1	3
Yellowstone River:						
Sidney, Mont	9	16	25	2	5	7
Maximum	219	309	386	130	56	131
Minimum	0	2	2	0	0	0

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity, whereas fallout contributes primarily additional beta activity.

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*10*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*11*).

The rise of radioactivity levels expressed in pCi/liter at a particular station is often presumed to be associated with a corresponding increase in suspended solids. For example, the samples for November 1964 and January, February, and March 1965 from the Atchafalaya River at Morgan City, Louisiana, have shown increased alpha and beta activities in suspended solids when compared to results of other recent months. In order to verify and understand the meaning of these results, several steps were taken. Data from the nearest

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

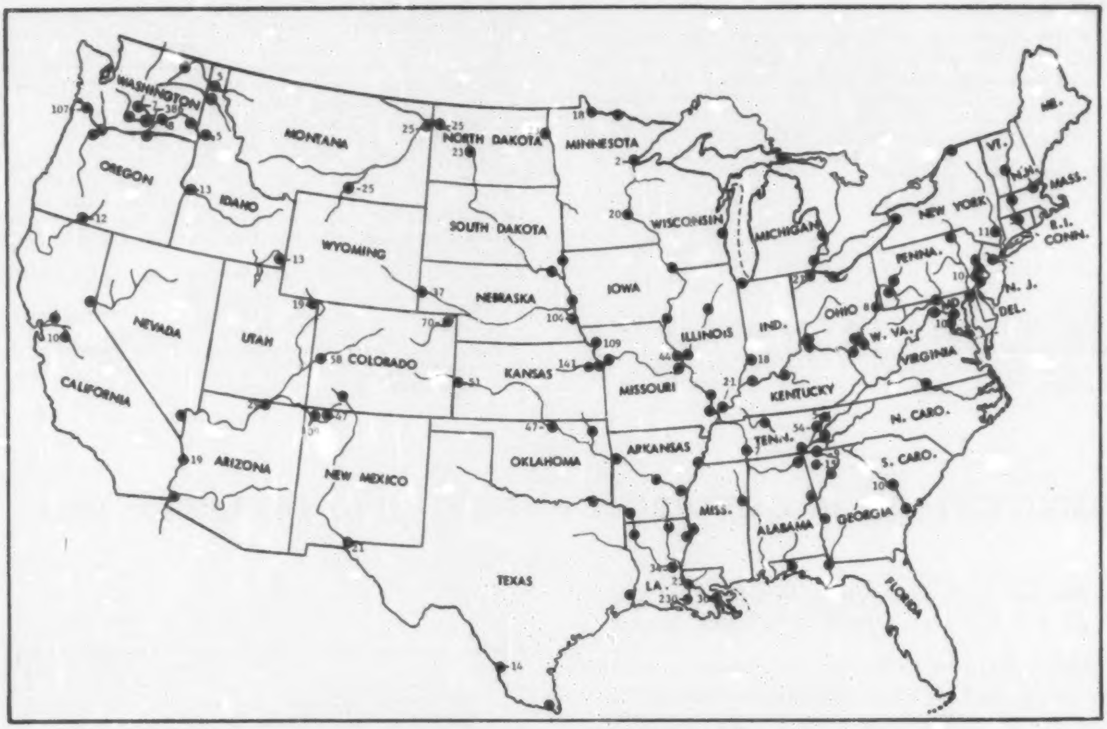
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Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, March 1965

upstream station (Alexandria, Louisiana) were also examined. The volumetric radioactivity in pCi/liter was converted to specific radioactivity in pCi/g of suspended solids. The average results over a six-month period from October 1964 through March 1965 yielded average specific alpha activities of 45 pCi/g of suspended solids for each station and average specific beta activities of 59 pCi/g of suspended solids for each station. During the same period, the average volumetric alpha activity was 60 pCi/liter and the average beta activity was 185 pCi/liter for suspended solids.

A three-month composite sample from Morgan City, Louisiana, which had been made up of weekly samples collected from October 1964 through December 1964 was analyzed in triplicate in order to verify the validity of the monthly determinations. The average specific alpha activity on suspended solids was 37 pCi/g and the average specific beta activity on suspended solids was 45 pCi/g. For comparison, the average volumetric alpha activity on suspended solids was 53 pCi/liter and the average volumetric beta activity on suspended solids was 147 pCi/liter. The agreement between determinations was excellent and agreement with the six-month averages at Morgan City, Louisiana, and Alexandria, Louisiana, was reasonable.

Although noticeable variations occurred in the volumetric radioactivity values, the specific radioactivity values in pCi/g of suspended solids did not show the same degree of change. Thus, the rise observed in the Atchafalaya River data presented in pCi/liter is obviously associated with the level of suspended solids in the water. In table 1 the following stations show relatively high values for alpha and beta radioactivity because of parallel high suspended solids: Morgan City, Los Angeles, De Soto, St. Joseph, Plattsmouth, and Shiprock. The dissolved solid levels in comparison to alpha and beta activity also show the same pattern, but in lesser degree.

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[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN CALIFORNIA WATERS,[1] JULY-DECEMBER 1964

Bureau of Radiological Health, State of California, Department of Public Health

Gross beta activity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout in open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters, and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling is being substituted or continued. This procedural change is predicted upon sampling water at the point of consumption.

Most of the supplies sampled have as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

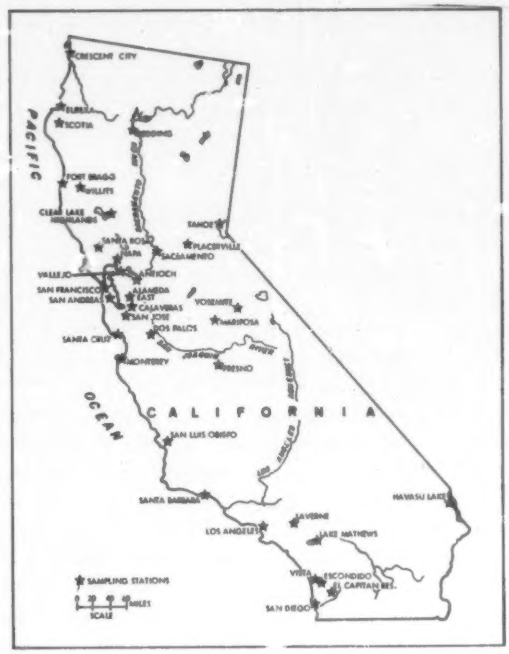
CRESCENT CITY
EUREKA
SCOTIA
REDDING
PACIFIC
FORT BRAGG
WILLITS
CLEAR LAKE HIGHLANDS
TAHOE
PLACERVILLE
SANTA ROSA
NAPA
SACRAMENTO
VALLEJO
ANTIOCH
SAN FRANCISCO
SAN ANDREAS
ALAMEDA EAST
CALAVERAS
SAN JOSE
YOSEMITE
MARIPOSA
DOS PALOS
SANTA CRUZ
MONTEREY
SAN JOAQUIN RIVER
FRESNO
OCEAN
C A L I F O R N I A
SAN LUIS OBISPO
LOS ANGELES
SANTA BARBARA
HAVASU LAKE
LAVERNE
LOS ANGELES
LAKE MATHEWS
VISTA
ESCONDIDO
EL CAPITAN RES.
SAN DIEGO
SAMPLING STATIONS
0 20 40 60 MILES
SCALE

Figure 1. California surface water sampling stations

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or

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[1] Data from "Radiological Health News," Vol. 4, No. 1 (January 1965), No. 2 (April 1965). California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Table 1. Gross beta activity in California domestic waters (pCi/liter), July–December 1964

Sampling station	Quality	July	August	September	October	November	December
Alturas	Well	[a] 16.2	[a] 6.8	NS	NS	[a] 8.9	[a] 4.9
Antioch	Raw	NS	ND	ND	[a] 6.3	ND	[a] 8.3
	Treated	NS	[a] 6.4	[a] 1.5	ND	[a] 2.7	[a] 0.8
Arrowhead Lake	Treated	[a] 2.5	NS	[a] 14.2	NS	30.6	NS
Berkeley	Treated	[a] 5.1	[a] 2.9	[a] 19.1	[a] 11.6	[a] 5.6	NS
Clearlake Highlands	Raw	ND	[a] 9.3	[a] 7.4	[a] 12.0	[a] 10.1	[a,b] 15.8
Crescent City	Raw	[a] 8.1	ND	ND	[a] 2.6	[a] 1.6	[a] 8.3
Death Valley	Treated	NS	NS	NS	NS	NS	ND
Dos Palos	Treated	[a] 5.8	ND	[a] 0.8	[a] 1.3	[a] 7.1	[a] 9.4
El Centro	Raw	[a] 13.5	ND	NS	NS	NS	NS
	Treated	[a] 2.7	ND	[a] 14.6	[a] 15.0	[a] 9.6	[a] 26.0
Eureka	Raw	[a] 2.4	ND	ND	ND	[a] 1.6	[a] 12.5
	Treated	[a] 15.8	[a] 1.4	[a] 0.7	[a] 15.0	[a] 7.9	ND
Fort Bragg	Raw	ND	ND	[a] 0.9	NS	NS	[a] 8.0
Los Angeles Laboratory	Treated	[a,b] 14.4	NS	[a,b] 4.8	ND	NS	[a] 9.0
Marin Municipal Water District:							
Corte Madera	Treated	[a] 5.3	[a] 5.0	NS	[a] 13.6	[a] 2.4	NS
Mariposa	Raw	[a] 18.1	23.0	NS	ND	[a] 7.2	NS
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	NS	[a] 0.6	[a] 8.8	[a] 7.1	[a] 2.3	NS
Lake Matthews	Raw	ND	[a] 4.3	[a] 2.4	[a] 22.7	[a] 19.6	NS
Lake Millerton	Raw	[a] 19.6	[a] 8.1	[a] 15.4	[a] 13.0	NS	[a] 8.3
Monterey	Raw	ND	[a] 1.3	ND	[a] 4.1	NS	[a] 8.1
Napa	Raw	[a,b] 8.5	[a,b] 3.6	NS	NS	[a] 12.2	[a] 2.6
Needles	Treated	[a] 12.8	NS	NS	NS	NS	NS
North Marin Water District	Well	[a] 18.5	[a] 2.4	ND	[a] 7.2	[a] 17.3	ND
	Raw	[a] 0.7	[a] 5.7	[a] 14.9	[a] 10.9	[a] 13.6	[a] 8.9
	Sludge	17.0	71.6	[a] 25.6	[a] 34.2	[a] 53.0	[a] 102.4
Oroville:							
Wyandotte Irrigation District	Raw	[a] 6.2	[a] 9.6	[a] 12.4	NS	[a] 2.0	[a] 1.7
California Water Service	Raw	NS	ND	NS	[a] 0.5	NS	[a] 11.2
Placerville	Raw	NS	NS	NS	NS	NS	NS
Redding	Raw	[a] 17.1	[a] 7.5	[a] 11.0	56.3	5.6	[a] 3.4
Sacramento	Raw	[a] 5.0	[a] 3.9	ND	[a] 2.7	[a] 3.3	NS
San Diego	Treated	[a] 8.5	[a] 25.5	ND	33.9	[a] 8.1	NS
San Francisco:							
Water Department	Treated	ND	[a] 3.2	NS	NS	ND	NS
Alameda, East	Treated	[a] 15.1	57.7	NS	[a] 16.2	24.7	NS
Brightside Weir	Raw	ND	[a] 5.3	NS	ND	ND	NS
Calaveras Reservoir	Raw	[a] 8.4	93.4	NS	ND	[a] 7.8	NS
Crystal Springs	Raw	[a] 3.1	NS	NS	NS	NS	NS
Crystal Springs Line No. 1	Raw	NS	[a] 13.5	NS	[a] 15.3	ND	NS
Crystal Springs Line No. 2	Raw	NS	NS	NS	NS	NS	NS
Hetch Hetchy	Raw	42.7	NS	[a] 7.2	NS	[a] 14.3	[a] 14.1
Moccasin	Raw	NS	NS	NS	NS	NS	NS
San Andreas Line No. 1	Raw	NS	NS	NS	NS	NS	NS
San Jose	Raw	ND	ND	[a] 8.5	NS	NS	ND
San Luis Obispo	Raw	[a] 8.4	[a] 4.3	[a] 5.7	NS	29.1	[a] 5.2
Santa Barbara	Raw	[a] 15.6	ND	[a] 7.6	[a] 8.2	ND	[a] 11.0
Santa Cruz	Coastal	ND	NS	ND	NS	ND	NS
	Raw	[a] 6.3	ND	ND	[a] 7.2	NS	ND
	Treated	ND	[a] 6.4	[a] 6.0	ND	NS	[a] 13.8
Santa Rosa	Raw	[a] 13.3	[a] 6.9	ND	ND	[a] 5.4	ND
	Treated	ND	[a] 6.6	[a] 5.9	7.0	[a] 4.9	ND
Scotia	Raw	[a] 14.2	ND	ND	[a] 11.0	45.6	NS
	Treated	NS	NS	NS	NS	NS	[a] 2.6
Tahoe City	Raw	[a] 12.5	NS	NS	NS	ND	NS
Ukiah	Well	[a] 1.6	[a] 8.7	ND	ND	ND	ND
Vallejo:							
Fleming Hill	Raw	[a] 13.0	[a] 5.4	NS	ND	ND	NS
	Treated	[a] 10.3	ND	[a] 3.0	[a] 0.5	[a] 4.8	NS
Swanzy Reservoir	Raw	[a] 0.4	[a] 6.8	[a] 14.0	[a] 11.4	[a] 5.0	NS
Willits	Raw	ND	ND	ND	ND	[a] 11.7	[a] 11.8
Yosemite	Raw	22.7	7.0	[a] 14.6	[a] 8.9	[a] 13.9	[a] 10.6
Maximum		42.7	57.7	25.6	56.3	53.0	102.4
Minimum		0	0	0	0	0	0

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Average of more than one sample for the month.

Key to Symbols: ND—Non-detectable
NS—No sample collected

surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, three-liter samples are collected monthly for approximately six months and composited for specific radionuclide analysis on a biannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta activities are made with a low-background windowless gas-flow proportional counter. Counting methods used are in accordance with U.S. Public Health Service recommended procedures (*1*).

Individual samples are evaporated down to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta counting. Gamma-emitting radionuclides are determined biannually on the composite samples.

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in raw surface water in California from July through December 1964. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water has been observed in spite of some increase in fallout.

REFERENCES

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Recent coverage in *Radiological Health Data:*

Period	Issue
1961–June 1962	*April 1963*
July–December 1962	*September 1963*
January–June 1963	*March 1964*
July–December 1963	*September 1964*
January–June 1964	*March 1965*

RADIOACTIVITY IN NEW YORK SURFACE WATER JUNE–DECEMBER 1964

Division of Environmental Health Services
State of New York Department of Health

The New York Department of Health began a program in 1953 to determine the amount of radioactivity in water used for public consumption. This radioactivity in water may arise from the natural mineral content of water (background), from atmospheric fallout, and from nuclear industry operations. Water samples are obtained from 26 locations for gross beta analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium-90 analyses.

Analytical procedures

Beta activity concentrations are determined by evaporating a known volume of water to dryness and counting in an end-window, gas-flow proportional counter.

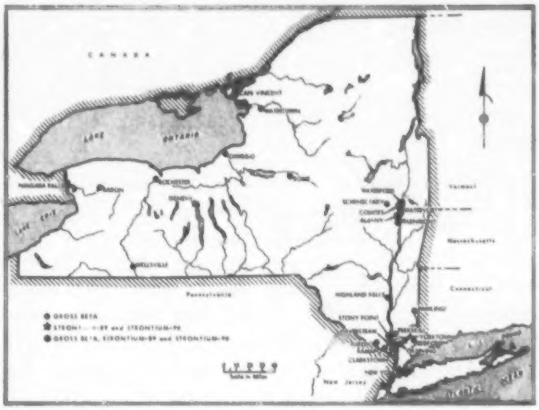
CANADA
LAKE ONTARIO
CAPE VINCENT
OSWEGO
ROCHESTER
GENEVA
NIAGARA FALLS
LAKE ERIE
WELLSVILLE
Pennsylvania
WATERFORD
SCHENECTADY
COHOES
ALBANY
Vermont
Massachusetts
Connecticut
HIGHLAND FALLS
STONY POINT
CLARKSTOWN
NEW YORK
New Jersey
ATLANTIC OCEAN
GROSS BETA
STRONTIUM-89 and STRONTIUM-90
GROSS BETA, STRONTIUM-89 and STRONTIUM-90
Scale in Miles

Figure 1. New York water sampling locations

Table 1. Gross beta activity concentrations in New York raw surface water, July–December 1964

Location	Sampling	Concentration pCi/liter					
		July	August	September	October	November	December
Akron (Murder Creek)	BW	12	12	11	9	9	10
Bedford (Byram Lake)	M	4		9	10	13	8
Cape Vincent (St. Lawrence River)	M				5		
Clarkstown (Congers Lake)	M	22		20			
Clarkstown (Lake De Forest)	M	11		11		8	6
Cohoes (Mohawk River)	C	6		8	9	8	6
Glenmont (Hudson River)	D	8		8	7	8	6
Haverstraw (Letchworth V. Res.)	M	6		5		2	6
Highland Falls (Bog Meadow Brook)	M	4		4	5	6	5
Niagara Falls (W. Branch Niagara River)	M			7		3	
Niagara Falls (E. Branch Niagara River)	M			9		4	
Ossining (Hudson River) (Sing Sing)	BW	57	64	61	66	60	62
Ossining (Indian Brook Res.)	M	17		12	7	6	7
Oswego (Lake Ontario)	W			7	5	5	5
Pawling (Pond at United Nuclear)	M	4		8	3	5	
Peekskill (Hudson River)	W	28		43	48	51	44
Peekskill (Camp Fields WS)	W	10		6	5	4	7
Ramapo (Hillburn WS)	M	7		5		2	
Rome (Fish Creek)	BW	8		8	5	6	8
Schenectady (Mohawk River)	C	11		8	8	6	6
Stony Point (Iowa Is. W.S.)	M	2		3		3	3
Tuxedo (Indian Kill Outfall)	C			10	11	10	11
Waterford (Hudson River)	BW	10		7	6	5	5
Watertown (Black River)	M	8		9	7	8	7
Watervliet (Fr. Mills Res.)	M	5		5	5	5	5
Yorktown (Croton Res.)	W	13		9	9	8	6

Key to symbols: BW—Biweekly composite of daily grab samples
M—Monthly grab sample
C—Continuous bleed-off analyzed weekly
D—Weekly composite of daily grab samples
W—Weekly grab sample
Blanks indicate no sample collected

For strontium-89 and strontium-90 determinations, a measured volume of water is passed through an ion exchange column. The radiostrontium is complexed on the resin as strontium sulfate. The strontium is then eluted from the resin. The resultant solution is concentrated and subsequently counted in a low background, end-window, gas-flow proportional counter. Successive countings at two day intervals facilitate the determination of the strontium-90 and strontium-89 concentrations.

Discussion and results

The observed gross beta activity concentrations in New York surface water for July–December 1964 are given in table 1. It is of interest to note that the Cohoes gross beta results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water.

The observed strontium-89 and strontium-90 concentrations in New York water for June through December 1964 are presented in tables 2 and 3.

Table 2. Strontium-89 concentrations in New York water, June–December 1964

Sampling location	Radionuclide concentration, pCi/liter						
	June	July	Aug	Sept	Oct	Nov	Dec
Albany	<3	<3	NS	<3	<3	<3	<3
Cohoes	<3	<3	<3	NA	<3	<3	<3
Geneva	<3	<3	<3	<3	6	<3	<3
New York City	<3	<3	NS	<3	<3	<3	<3
Additional sites:							
Ashford	—	—	—	—	<3	<3	<3
East Otto	—	—	—	<3	<3	<3	<3
Ellicottville	—	—	—	<3	<3	NS	<3
Franklinville	—	—	—	<3	<3	<3	<3

Key to symbols: NA—No analysis
NS—No sample collected
— Station not in operation

Table 3. Strontium-90 concentrations in New York water, July–December 1964

Sampling location	Radionuclide concentration, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	<3	<3	NS	<3	<3	3
Cohoes	<3	4	<3	NA	5	<3
Geneva	<3	<3	<3	<3	<3	<3
New York City	<3	5	NS	<3	<3	<3
Additional sites:						
Ashford	—	—	—	<3	<3	<3
East Otto	—	—	<3	5	<3	<3
Ellicottville	—	—	<3	<3	NS	<3
Franklinville	—	—	<3	6	<3	<3

Key to symbols: NA—No analysis
NS—No sample collected
— Station not in operation

Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for the Argonne National Laboratory, Atomics International, and the National Reactor Testing Station.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentrations limits, are applicable to effluents released from AEC installations.

1. Argonne National Laboratory[2]
July–December 1964

University of Chicago
Lemont, Illinois

The radioactivity of the environment at and near Argonne National Laboratory (ANL) is determined on a continuing basis by measuring the radioactivity levels in air, water, and raw milk. The sampling locations for air and water are shown in figures 1 and 2.

Air monitoring

Air filter samples are collected continuously at seven locations on the Argonne site and at five locations off the site. The total alpha and beta activities are summarized in table 1. The data show little difference between offsite and onsite measurements, indicating that ANL does not contribute more than negligible quantities of radioactive materials to the atmosphere.

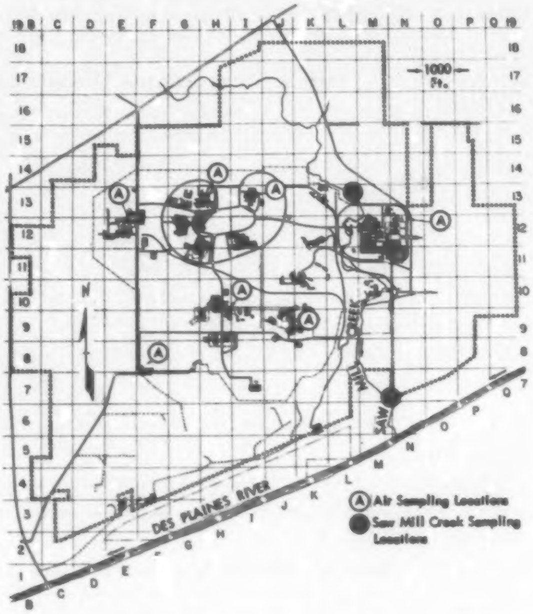

Figure 1. Onsite sampling locations, Argonne National Laboratory

Water monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge to evaluate the effect of the waste water on the radioactivity in the Creek.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1964," University of Chicago, Lemont, Illinois.

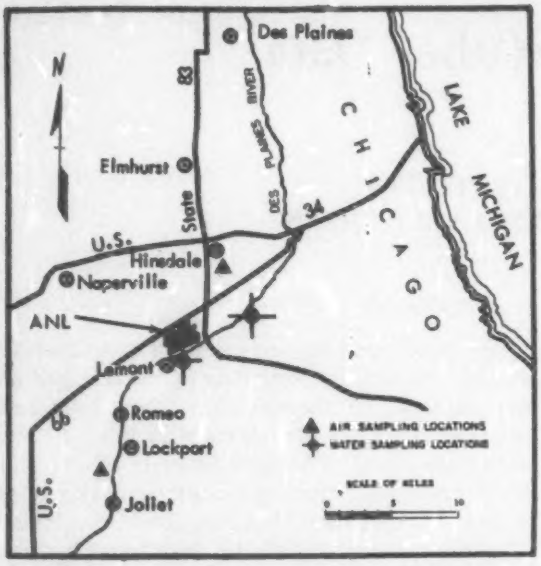

Figure 2. Site locations of Argonne National Laboratory (including some offsite sampling stations)

On Sawmill Creek, the upstream flow is roughly equal to the waste water flow, yielding a twofold dilution. The data in table 2 show significantly higher concentrations downstream from the waste water discharge, an indication of the radioactivity contributed to the stream by ANL. Nevertheless, a comparison of the downstream concentrations with permissible environmental concentrations shows that all concentrations are relatively low.

Samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results shown in tables 2 and 3 indicate that dilution by the Des Plaines River is large enough to reduce radioactivity contributed from ANL to undetectable levels.

Milk monitoring

Three samples of raw milk produced in the area are analyzed monthly for a number of

Table 1. Total alpha and beta activities in air filter samples, July–December 1964[a]

(pCi/m³)

Period	Location	No. of Samples	Alpha activity			Beta activity		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	30	0.0032	0.0010	0.0058	1.0	0.6	1.8
	Offsite	23	0.0038	0.0025	0.0056	1.0	0.7	1.7
August	Onsite	24	0.0028	0.0018	0.0043	0.6	0.4	0.8
	Offsite	22	0.0033	0.0022	0.0048	0.6	0.5	0.9
September	Onsite	27	0.0027	0.0015	0.0050	0.3	0.2	0.5
	Offsite	23	0.0027	0.0013	0.0049	0.3	0.2	0.5
October	Onsite	23	0.0037	0.0015	0.0060	0.4	0.2	0.9
	Offsite	22	0.0038	0.0021	0.0077	0.4	0.2	0.7
November	Onsite	24	0.0043	0.0024	0.0075	0.5	0.2	1.3
	Offsite	20	0.0040	0.0019	0.0086	0.5	0.2	1.2
December	Onsite	26	0.0037	0.0024	0.0053	0.2	0.1	0.3
	Offsite	22	0.0043	0.0026	0.0057	0.2	0.2	0.3
July-December summary	Onsite	154	0.0034	0.0010	0.0075	0.5	0.1	1.8
	Offsite	132	0.0037	0.0013	0.0086	0.5	0.2	1.7

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within four days by radioactive decay.

Table 2. Nonvolatile alpha and beta activity in Sawmill Creek water, July–December 1964

Period	Location	No. of Samples	Alpha activity, pCi/liter			Beta activity, pCi/liter		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	5	1.1	0.4	1.5	26	16	34
	Downstream	15	1.4	0.8	2.2	177	10	593
August	Upstream	4	0.8	0.6	1.0	11	10	12
	Downstream	12	0.4	1.1	2.4	222	41	754
September	Upstream	5	1.0	0.2	2.1	16	7	32
	Downstream	12	2.0	1.1	3.7	93	39	218
October	Upstream	4	1.9	0.3	2.9	13	8	20
	Downstream	15	3.6	1.7	8.3	43	26	66
November	Upstream	4	1.8	1.5	2.2	13	7	17
	Downstream	12	3.2	1.6	4.7	26	17	29
December	Upstream	3	2.2	1.8	2.7	18	13	24
	Downstream	15	2.4	1.3	4.1	22	20	27
July-December summary:	Upstream	25	1.5	0.2	2.9	16	7	34
	Downstream	81	2.3	0.8	8.3	96	10	754

Table 3. Nonvolatile alpha and beta activity in Des Plaines River water, July–December 1964

Period	Location	No. of Samples	Alpha activity, pCi/liter			Beta activity, pCi/liter		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	5	1.9	0.3	3.7	37	31	46
	Downstream	5	1.8	0.8	2.5	34	33	37
August	Upstream	4	3.3	2.0	7.0	41	33	57
	Downstream	4	2.1	0.8	3.9	29	26	34
September	Upstream	5	1.8	1.0	2.6	29	25	36
	Downstream	5	2.3	1.4	3.1	31	25	40
October	Upstream	4	3.2	2.9	3.4	31	26	34
	Downstream	4	1.9	1.5	2.3	26	21	31
November	Upstream	4	2.0	1.2	2.5	38	20	59
	Downstream	4	1.6	0.9	2.6	29	24	31
December	Upstream	2	2.3	2.3	2.3	22	21	23
	Downstream	5	2.1	0.5	3.1	21	18	27
July-December summary:	Upstream	24	2.4	0.3	7.0	33	20	59
	Downstream	27	2.0	0.5	3.9	29	18	40

fission products. Only the long-lived fission products, cesium–137 and strontium–90, have been detected. The concentrations of these two nuclides are shown in table 4. These activities are due to fallout from nuclear detonations and are not related to Argonne operations.

Table 4. Cesium-137 and strontium-90 in raw milk, July–December 1964

Date collected	Cesium-137, pCi/liter		Strontium-90, pCi/liter	
	Average	Maximum	Average	Maximum
July 3	330	360	15	17
August 7	195	200	15	16
September 4	155	205	13	14
October 2	120	155	11	13
November 17	130	140	13	16
December 9	200	215	14	16

Summary

Argonne's contribution to environmental radioactivity is generally confined to Sawmill Creek below the waste water discharge. Radioactivity originating at Argonne was not found in any other material or at any other location off the site. The concentrations of radioactive substances added to the environment by Argonne were considerably less than the maximum permissible concentrations and did not constitute a health hazard.

Recent coverage in *Radiological Health Data:*

Period	Issue
Second half 1960	*July 1961*
First half 1961	*December 1961*
Second half 1961	*May 1962*
Calendar year 1962	*May 1963*
Calendar year 1963	*August 1964*
First half 1964	*March 1965*

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2. Atomics International[3]
July–December 1964

North American Aviation, Incorporated
Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific application. Locations of the facilities are shown in figure 3.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor, several smaller experimental reactor facilities and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of the Company's radiological safety procedures

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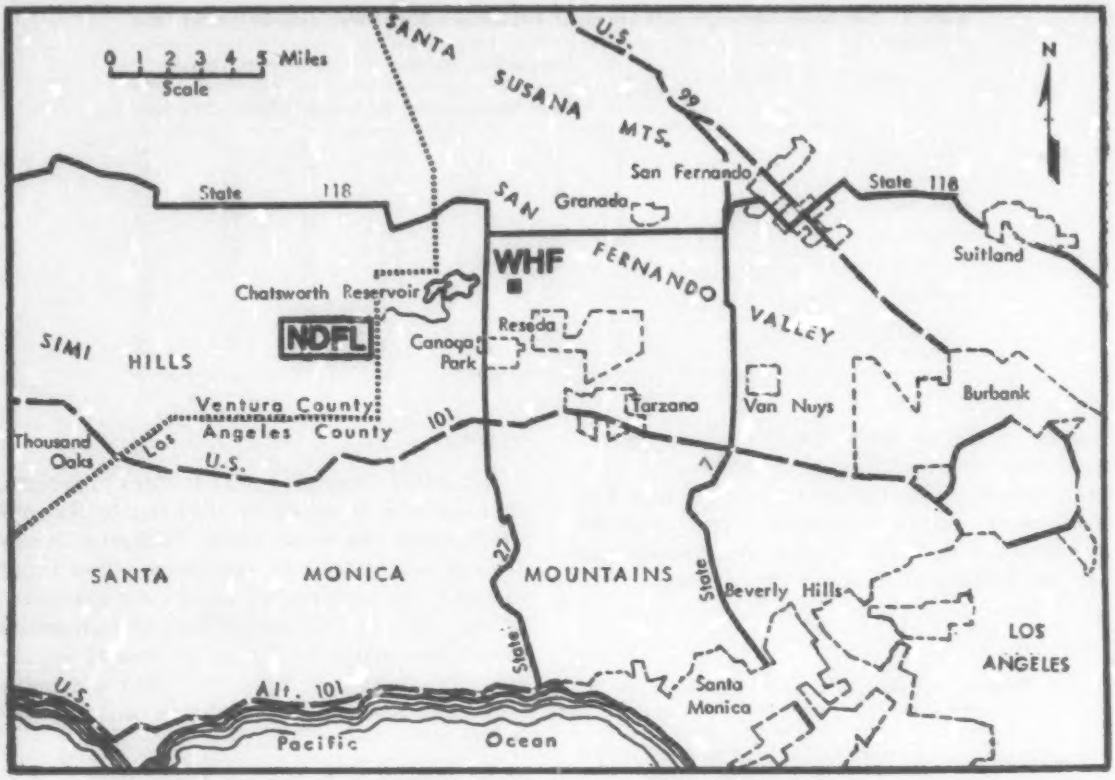
[3] Summarized from "Environmental Monitoring, Semiannual Report, July 1, 1964 to December 31, 1964," Atomics International.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SIMI HILLS
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
101
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Thousand Oaks
SANTA MONICA MOUNTAINS
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Beverly Hills
LOS ANGELES
U.S.
Alt. 101
Santa Monica
Pacific Ocean

Figure 3. Atomics International facilities and vicinity

and of engineering safeguards incorporated into the facility. This program consists of periodic sampling of air, water, soil, and vegetation in the environs of these two installations.

Air monitoring

Environmental air sampling is conducted continuously with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. Airborne radioactivity concentrations remained low with little daily variation. The average concentration of beta and gamma activity at Canoga Park during the second half of 1964 was 0.71 pCi/m³.

Water monitoring

Process water at the NDFL is obtained from wells and stored in 50,000-gallon tanks. Monthly samples are collected from these wells. Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one-liter polyethylene bottles for transfer to the laboratory, as are water samples from the lake surface and supply inlet of Chatsworth Reservoir. The results from the analysis of all water samples are shown in table 5. In some cases the

Table 5. Radioactivity in water samples
July–December 1964

Source	Average activity (pCi/liter)	
	Alpha	Beta-gamma
NDFL wells	0.22	6.8-7.0
Chatsworth Reservoir surface	0.83	8.8
Chatsworth Reservoir supply inlet	0.59	7.8

average concentration is presented as a range. A range is recorded when one or more of the samples analyzed contains an undetectable amount of radioactivity. The lower value is obtained by assuming that the "undetectable" samples contain no radioactivity; the higher, by assuming that these samples contain radioactivity equal to the appropriate minimum detection limit.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly. Surface soil samples are collected from the top half-inch layer of ground surface. The results from soil analysis are shown in table 6.

Table 6. Radioactivity in soil samples July–December 1964

Area	Average activity (pCi/g)	
	Alpha	Beta-gamma
Onsite	0.54–0.55	29
Offsite	0.45–0.49	19

Vegetation samples obtained in the field are of the same plant type wherever possible—generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than does most natural vegetation indigenous to the local area. These samples are washed and ashed before analysis. The results from vegetation analysis are shown in table 7.

Table 7. Radioactivity in vegetation samples July–December 1964

Area	Average activity (pCi/g ash)	
	Alpha	Beta-gamma
Onsite	0.61–0.62	175
Offsite	0.63–0.64	130

Recent coverage in *Radiological Health Data:*

Period	Issue
Calendar year 1960 and first half 1961	*December 1961*
Second half 1961	*August 1962*
Calendar year 1962	*November 1963*
Calendar year 1963	*September 196*
First half 1964	*March 1965*

3. National Reactor Testing Station[4]
July–December 1964

Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodical sampling of ground and surface waters, milk, air, and wheat. The locations at which these samples are taken are shown in figure 4. The results of the analysis of these samples, with the exception of wheat (not sampled during this period), are shown in table 8.

Offsite well water monitoring

Low-level liquid wastes resulting from operation of the various facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Although liquid wastes are monitored at the NRTS before disposal, offsite underground samples are collected regularly. Most of these samples are taken from an area southwest of the NRTS since this is the prevalent direction of underground water flow. During the second half of 1964, the average concentrations of alpha and beta emitters were no more than 40 percent and 0.3 percent respectively of the applicable concentration guides. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite well water monitoring

Onsite samples were taken from the plant production wells in order to monitor potable water for detection and definition of possible sources of contamination. Analyses of these

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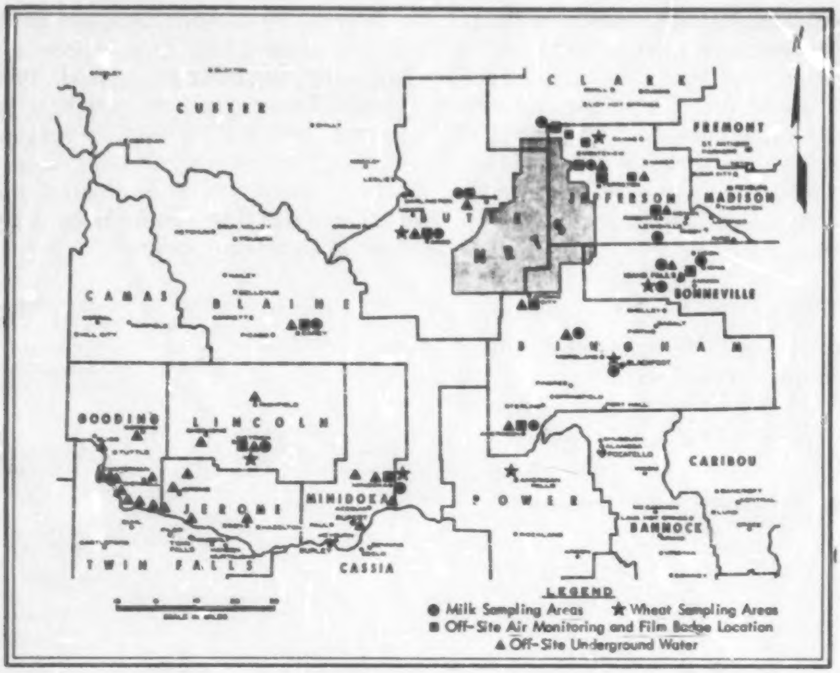
[4] Summarized from "Environmental Monitoring Report No. 15, Third and Fourth Quarter and Annual Summary 1964." U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.


CUSTER
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MADISON
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BONNEVILLE
CAMAS
BLAINE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
POWER
POCATELLO
CARIBOU
BANNOCK
TWIN FALLS
CASSIA
LEGEND
● Milk Sampling Areas
★ Wheat Sampling Areas
■ Off-Site Air Monitoring and Film Badge Location
▲ Off-Site Underground Water

Figure 4. Environmental monitoring stations, National Reactor Testing Station

Table 8. Environmental monitoring data for the National Reactor Testing Station, July–December 1964

Type of sample	Number of stations	Approximate frequency of collection	Total number of samples	Maximum activity	Average activity per sample	Applicable concentration guides
Offsite well water	32	Semiannual	32	α:4 x 10^{-9} pCi/ml β:2 x 10^{-9} pCi/ml	α: <4 x 10^{-9} pCi/ml β: <1 x 10^{-9} pCi/ml	α:10 x 10^{-9} pCi/ml β:300 x 10^{-9} pCi/ml
Onsite well water	22	Two weeks	237	α:5 x 10^{-9} pCi/ml β:8 x 10^{-9} pCi/ml	α: <4 x 10^{-9} pCi/ml β: <1 x 10^{-9} pCi/ml	α:100 x 10^{-9} pCi/ml β:3000 x 10^{-9} pCi/ml
Offsite air	15	Continuous		Particulate β-γ: 37 x 10^{-6} pCi/ml Gaseous iodine: 5 x 10^{-6} pCi/ml	Particulate β-γ: <5 x 10^{-6} pCi/ml Gaseous iodine: <4 x 10^{-6} pCi/ml	Particulate β-γ: 100 x 10^{-6} pCi/ml Gaseous iodine: 100 x 10^{-6} pCi/ml
Offsite milk	14	Monthly	80	Iodine-131: <20 pCi/liter	Iodine-131: <20 pCi/liter	Iodine-131: 100 pCi/liter
Offsite area monitoring badges	11	Monthly	[a] 73	Strontium-90: 26 pCi/liter	Strontium-90: 16 pCi/liter	Strontium-90: 200 pCi/liter
	14	Quarterly	27	γ: 150 mR/yr β: <40 mrad/yr	γ: 80 mR/yr β: 40 mrad/yr	γ: 500 mR/yr β: 3000 mrad/yr

[a] Total samples analysed for strontium-90 include month of June 1964.

samples showed that average concentrations of alpha and beta emitters were no more than 4 percent and 0.1 percent of their respective guide values.

Offsite air monitoring

During 1964, data reported electronically from the radiation monitoring telemetry system replaced data previously derived manually from offsite air samples collected by means of a dual filter and a low-volume vacuum pump. The telemetry system has many operating capabilities not available in the previous system. Normal operations call for hourly reports by each station. These reports include information from:

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- *Ion chambers:* These instruments measure ambient radiation levels in mr/hr.
- *GM counters:* HV–70 filter paper is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity over the day and another measures the decay of the activity collected the previous day.
- *Scintillation counter:* Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity measured is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 telemetry stations indicate that the sum of the average concentration of gaseous iodine–131 and particulate activity in the atmosphere was no greater than 9 percent of the applicable concentration guide of 100×10^{-6} pCi/ml.

Offsite milk monitoring

Analyses of iodine–131 and strontium–90 concentrations in milk were made on a monthly basis. Of the 80 analyses for iodine–131, no sample was found to have a concentration greater than 20 pCi/liter, or 20 percent of the applicable concentration guide. Of the 73 milk samples analyzed for strontium–90, the maximum activity was found to be 26 pCi/liter, or 13 percent of the applicable concentration guide.

Offsite area monitoring badges

Offsite film badges were collected on a quarterly basis during the second half of the year. The maximum radiation dose at a single location for the entire six-month period, as measured by the film, was 75 mR of gamma and <20 mrad of beta radiation. For the purpose of calculating the maximum dose, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location. Nevertheless, this dose is well below the RPG for an individual residing in the vicinity of an atomic energy installation.

Wheat monitoring

In the 6 samples of wheat analyzed during the entire year, strontium–90 levels ranged from 7 to 30 pCi/kg with an average of 11 pCi/kg. Cesium–137 levels varied from 95 to 200 pCi/kg with an average of 155 pCi/kg. Manganese–54 concentrations varied from 500 to 1,200 pCi/kg with an average of 790 pCi/kg. The presence of these radionuclides in wheat is attributed to worldwide fallout resulting from the atmospheric testing of nuclear weapons. A comparison of data from 1964 with that from the previous years indicates that while the levels of strontium–90 and cesium–137 decreased by a factor of 3 to 5, the manganese–54 content almost doubled. Although there is no ready explanation for this increase, selective uptake of manganese from the soil might be responsible. Although specific guidance pertaining to wheat has not been established, the data indicate that wheat is not a significant contributor to the radiation dose received by the local population.

Previous coverage in *Radiological Health Data:*

Period	Issue
Second half 1960	*May 1961*
First half 1961	*January 1962*
Second half 1961	*June 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
First half 1964	*March 1965*

REPORTED NUCLEAR DETONATIONS, AUGUST 1965

During August 1965 two United States nuclear tests were announced by the Atomic Energy Commission. Tests in the low-yield range (less than 20 kilotons) were conducted underground at the Commission's Nevada Test Site on August 6 and August 27, 1965.

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